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Truckee Meadows
(Reno-Sparks Metropolitan Area)
Nevada

US Army Corps of Engineers
Sacramento District

TRUCKEE MEADOWS INVESTIGATION
NEVADA

DOCUMENTATION REPORT

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PREPARED BY

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

Section A

Hydrology Office Report

SECTION A
HYDROLOGY OFFICE REPORT
TRUCKEE RIVER, CALIFORNIA AND NEVADA

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Chapter I - INTRODUCTION

1. Purpose and scope. - This office report has been prepared to present basic hydrologic data and criteria for the Truckee River Basin, California and Nevada. This data is intended for use in feasibility studies for providing additional flood protection to the Truckee Meadows area at and below Reno, Nevada. This report discusses the hydrologic characteristics of the basin, presents an analysis of flow-frequencies, and describes the development of standard project and probable maximum floods resulting from winter type rain storms and summer-fall type cloudbursts. An analysis of spring snowmelt floods is not required for this study since these types of floods are essentially non-damaging in the Truckee Meadows area under existing conditions of upstream regulation.

2. Previous studies. - Several earlier studies of the Truckee River Basin have been conducted by this office. Reports pertaining to hydrologic studies are tabulated below.

a. Office Report, Truckee River Basin, California and Nevada, Standard Project Flood, Truckee River at Reno, Nevada, July 1957.

b. Interim Survey Report for Flood Conrol, Reno Area, Truckee River and Tributaries, California and Nevada, Appendix A, Hydrology, March 1960.

c. Flood Plain Information, Truckee River, Reno-Sparks-Truckee Meadows, Nevada, October 1970.

d. Master Report on Reservoir Regulation for Flood Control, Truckee River Reservoirs, Nevada and California, December 1971.

e. Flood Plain Information, Steamboat Creek and Tributaries, Steamboat and Pleasant Valleys, Nevada, June 1972.

f. Flood Plain Information, Truckee River and Martis Creek, Truckee, California, June 1974.

CHAPTER II

DESCRIPTIVE HYDROLOGY

3. Description of area. -

a. General. - The Truckee River Basin, shown on chart 1, is located in eastern California and western Nevada. The river drains about 1,070 square miles of mountainous terrain above Reno including about 500 square miles above the Lake Tahoe outlet. Most of the runoff from the basin originates on the eastern slopes of the Sierra Nevada, which rise to over 10,000 feet in this region. Lake Tahoe effectively controls all rainfloods originating above it. The Truckee River begins at the outlet of Lake Tahoe, located on the northwestern shore of the lake, where an outlet structure regulates flow into the river. From the lake, the river flows about 15 miles in a northerly direction to the town of Truckee, California, then northeasterly about 40 miles to the City of Reno, Nevada. Below Reno the river flows about 50 miles easterly and northerly to Pyramid Lake, a remnant of prehistoric Lake Lahontan. The stream basin has no outlet to the sea. The main tributaries below Lake Tahoe are the Little Truckee River, Prosser, Donner, Martis, and Steamboat Creeks. Near Reno the river enters a vast meadow, the western and northern sections of which are occupied by the cities of Reno and Sparks. The eastern portion of the meadow, which is known as Truckee Meadows, is low in elevation and poorly drained. During large runoff periods this area is flooded extensively.

The largest tributary to the Truckee River in the Reno area is Steamboat Creek. This stream originates at the outlet of Washoe Lake, a large flat depression that stores all flood runoff originating above it, drains the southern and eastern part of Truckee Meadows, and enters the Truckee River near Vista. Evans, Dry, Thomas, Whites and Galena Creeks are tributaries to Steamboat Creek and originate on the northeastern slopes of Mt. Rose. Evans and Dry Creek combine below Highway 395 to form Boynton Slough.

North Truckee Drain consists of a natural channel, now largely improved and realigned to provide better drainage of Spanish Springs Valley and the northeasterly sector of Truckee Meadows.

Stream channels in the Truckee River system range from the precipitious tributaries discharging into Lake Tahoe, with slopes of more than 500 feet per mile, to the comparatively flat slopes of less than 10 feet per mile in the lower Truckee River near Pyramid Lake. Streambed profiles of the river system are shown on chart 2.

The major population centers in the basin are located at Reno and around Lake Tahoe. Elsewhere, population is sparse with only a few small towns and settlements. The principal economic activities in the Reno-Truckee Meadows area are the gaming and warehousing industries. Elsewhere in the basin, tourism, gaming, lumbering, farming, and ranching are the primary economic activities.

b. Geology. - In early geologic times, the Sierra Nevada had a low relief and formed the western slopes of lakes which occupied the Great Basin. The present range came into being about the beginning of the

Quaternary Period after an era of intense volcanic activity and crustal folding. It is composed largely of granite rock, massive granite batholiths having invaded the folds of the ancestral range during the period of mountain building. Subsequent erosion of the older rock covering has exposed the granites over large areas. Blockfaulted depressed areas filled with gravel and alluvium by the streams which flow through them form the valleys which exist today.

c. Topography. - The Sierra Nevada near the headwaters of the Truckee River tributaries is characterized by rugged rocky peaks, precipitous cliffs, steep canyons, and occasional small meadows and lakes. The lower portion of the basin consists of scattered valleys and dry lakebeds separated by mountain ranges. Elevations within the basin range from 3,900 to over 10,000 feet. About half of the area tributary to the Truckee River between Lake Tahoe and Lawton is about 6,500 feet, but only 10% is above 8,000 feet. Topography and area-elevation curves are shown on charts 3 and 4, respectively.

d. Soils and vegetative cover. - Much of the high mountain area is barren and has little soil cover, although where soil depths and precipitation are adequate, good stands of conifers exist. Below about elevation 5,000 feet, precipitation is sufficient for only sage brush and other desert shrubs. Valleys and meadows watered by running streams produce growths of native grasses. In the lower valleys, the native vegetation has been replaced to a considerable extent by irrigated crops. Most of the soils are alluvial, consisting of materials eroded from the mountainous areas.

Some lake sediments laid down by ancient Lake Lahontan, which covered a large portion of the state of Nevada, are found along with the alluvial soils. Soils of the valleys are classified as gravelly or sandy loams on the alluvial slopes, and as silty or clay loams on the bottom lands. They are naturally very fertile, and, in general, are not strongly alkaline, although, without proper drainage, alkali concentrations may reduce their productivity.

4. Flood control and related water resources development. - Flood control and conservation developments in the basin are summarized in the following paragraphs:

a. Projects completed by the Bureau of Reclamation in the Truckee River Basin are the Newlands project, the Truckee River storage project, and the Washoe project. The Newlands project, completed in 1915, consists of the Lake Tahoe outlet control structure; the 290,000 acre-foot Lahontan Reservoir and appurtenant power facilities on the Carson River near Fallon; the Derby Diversion Dam on Truckee River; the Truckee Canal extending from Derby Dam to Lahontan Reservoir; and the facilities for the distribution of irrigation water in the Carson River Basin in the vicinity of Fallon.

The Truckee River storage project, completed in 1939, consists of the 41,100 acre-foot Boca Reservoir on Little Truckee River, together with appurtenant distribution facilities for irrigation. Completed in 1970, the portion of the Washoe project above Reno consists of the 29,800 acre-foot Prosser Creek Reservoir on Process Creek and the 226,500 acre-foot Stampede Reservoir on Little Truckee River, about 4 miles upstream from Boca Reservoir. The completed three-reservoir complex of Boca, Stampede, and Prosser Reservoirs provides a total of 50,000 acre-feet of flood control

storage and additional flood protection to Reno, Sparks, and the Truckee Meadows area.

b. Developments by the Corps of Engineers include a channel modification project authorized by the Flood Control Act of 1954, consisting mainly of widening and deepening the Truckee River channel through Truckee Meadows for about 7.5 miles, extending from the downstream limits of Reno to a point near Vista; minor channel improvements at Lake Tahoe outlet; and minor channel improvements at intermittent points along the river above and below the Meadows area. This work was completed in 1963. Also, the Flood Control Act of 1962 authorized the 20,400 acre-foot Martis Creek Lake, completed in 1972, for flood control and future water supply.

c. Local interests provided channel improvements along the Truckee River, consisting of riprap and masonry retaining walls for stabilizing both banks through sections of the downtown Reno area. The work was accomplished about 1930 to 1935 by the Works Progress Administration in cooperation with local interests. As a part of the local interest requirements for Martis Creek project, the City of Reno additionally improved the channel to carry a 14,000 cubic feet per second (cfs) flow through Reno. This work was completed in 1972.

d. The Soil Conservation Service has constructed four flood detention reservoirs in the Peavine and East and West Wash watersheds north of Reno. These reservoirs contain a total of about 1,200 acre-feet of storage and provide flood protection to urban areas below the reservoirs.

e. There are other small reservoirs and lakes in the basin that contain very small amounts of storage and have no influence on flood flows on the streams of interest in this study.

5. Climate. - The upper part of the Truckee River Basin is characterized by severe winters and short, mild summers. Precipitation is markedly less than on the western slopes of the Sierra Nevada. The climate of the lower portion of the basin is typical of the Great Basin. The winters are long but with deficient precipitation, and the summers are short with practically no precipitation.

Temperatures vary considerably throughout the basin because of the extreme range in elevation, and diurnal variations are usually large. The minimum and maximum temperatures of record at Tahoe City (elevation 6,230 feet) are -15° F. and 94° F., and at Reno (elevation 4,400 feet) are -16° F. and 104° F., respectively. The monthly distribution of normal temperatures and observed temperature extremes at these two stations as well as at the Truckee Ranger Station and at Boca is illustrated in the following table:

TABLE 1

NORMAL 1/ MONTHLY TEMPERATURES (F°)

Month	Tahoe City (El. 6230')	Truckee R. S. (El. 5995')	Boca 2/ (El. 5575')	Reno WB AP (El. 4404')
January	26.9	25.6	23.7	30.4
February	28.4	28.0	26.8	35.6
March	32.2	32.7	31.8	41.5
April	38.8	39.7	39.9	48.0
May	45.7	46.6	47.2	53.9
June	53.0	54.1	53.6	60.1
July	60.9	61.9	60.1	67.7
August	60.0	60.4	58.0	65.5
September	54.3	55.3	52.8	58.8
October	45.0	45.6	44.7	49.2
November	35.3	35.0	35.3	38.3
December	30.3	28.5	28.1	31.9
Average Annual	42.6	42.8	41.8	48.4

1/ Normals for all stations are climatological normals based on the period 1931-1960 (as published by USWB).
2/ Boca values are averages for the period-of-record.

OBSERVED TEMPERATURE EXTREMES

Location	MAXIMUM F°	MAXIMUM Month	MINIMUM F°	MINIMUM Month
Tahoe City	94	August	-15	January
Truckee R.S.	101	August	-28	Jan. & Feb.
Boca	97	July	-45	January
Reno WB AP	104	July	-16	January

Normal annual precipitation over the drainage area between Lake Tahoe and Vista varies from 8 to 70 inches, with a basin mean of 26.5 inches. Precipitation usually falls as snow above elevation 5,000 feet, but some storms produce rain up to the highest elevations of the basin, and snowfall may occur anywhere in the basin.

The areal distribution of normal annual precipitation is shown on chart 5. In the upper part of the basin, about 85% of the annual precipitation falls during the winter months of November through April, but at Reno only 70% of the annual precipitation falls during this period. The normal monthly distribution is shown in the following table.

TABLE 2

NORMAL 1/ MONTHLY PRECIPITATION

Month	Tahoe City (El. 6230')		Truckee R.S. (El. 5995')		Boca 2/ (El. 5575')		Reno WB WP (El. 4404')	
	Inches	Percent	Inches	Percent	Inches	Percent	Inches	Percent
July	0.26	0.8	0.35	1.1	0.32	1.5	0.27	3.8
August	0.14	0.5	0.17	0.6	0.23	1.1	0.17	2.4
September	0.40	1.3	0.37	1.2	0.25	1.2	0.23	3.2
October	1.90	6.1	1.82	5.8	1.01	4.7	0.51	7.1
November	3.15	10.2	3.10	10.0	1.86	8.7	0.57	8.0
December	5.64	18.3	5.66	18.2	3.64	16.9	1.08	15.1
January	6.13	19.8	6.15	19.7	4.92	22.9	1.19	16.6
February	5.32	17.2	5.24	16.8	3.43	16.0	1.02	14.3
March	3.95	12.8	4.02	12.9	3.02	14.1	0.68	9.5
April	2.10	6.8	2.27	7.3	1.33	6.2	0.54	7.5
May	1.35	4.4	1.46	4.7	1.03	4.8	0.52	7.3
June	0.56	1.8	0.56	1.7	.42	1.9	0.37	5.2

1/ Normals of all stations are climatologic normals based on the period 1930-1960 (published by USWB).

2/ Boca values are averages for the period-of-record.

Winter snowfall above 5,000 feet elevation normally accumulates until about the first of April, when increasing temperatures mark the beginning of the snowmelt season. Snow falling at lower elevations usually melts within a relatively short time. Basin snowpack data for a wet year (1952), a dry year (1963), a near normal year (1953), and the average for 1 April at representative snow courses are given in Table 3.

6. Runoff. - Most of the runoff from the Truckee River watershed is derived from the snowpack which accumulates over the high mountain areas during the winter and melts during the late spring and early summer. A large part of the runoff of the Truckee River Basin originates above Farad, with about 31 percent above Lake Tahoe. Because of the regulatory effect of Lake Tahoe, outflows into Truckee River are normally minor except during snowmelt seasons of above-normal runoff. Annual runoff at Farad has varied from 133,000 acre-feet in 1931 to 1,432,000 acre-feet in 1907. Average monthly and annual runoff are illustrated in Table 4.

7. Streamflow data. - Streamflow records in the Truckee River Basin are available at the locations shown and listed on chart 6.

8. Precipitation data. - Precipitation records at stations in and adjacent to the Truckee River Basin have been published by the U.S. Weather Bureau since 1870. Locations and data pertinent to these stations are shown on chart 5.

TABLE 3

1 APRIL SNOW SURVEY DATA

(Truckee River Basin, California and Nevada)

No.	Snow Course	Elev. (Feet)	Snow Depth (Inches)			Water Equivalent (Inches)			Water Equivalent % of Average			Average* (Inches)
			1952	1953	1963	1952	1953	1963	1952	1953	1963	1 April
334	Mt. Rose	9,000	154	79	77	68.1	33.8	28.0	205	102	84	33.8
64	Webber Peak	7,800	184	106	61	86.8	43.5	20.5	197	99	46	44.4
69	Donner Summit	6,900	184	81	25	82.0	39.0	6.1	206	98	15	39.9
90	Sage Hen Cr.	6,500	113	53	24	45.3	21.0	5.0	240	111	26	18.3
92	Truckee #2	6,400	NR	41	21	NR	17.7	4.7	-	105	28	16.2
105	Tahoe City	6,250	89	30	16	38.6	14.6	2.9	327	124	25	11.1
95	Boca #2	5,900	61	7.0	T	25.0	3.8	T	472	72	0	4.8

*The average 1 April water content is for the period 1931-1971, as published in "California Snow Survey Measurement Schedule, 1971."

TABLE 4
Average Monthly Runoff (observed flows)

Month	Truckee River at Tahoe City, CA		Martis Cr. near Truckee, CA		Little Truckee R. above Boca Reservoir, CA		Truckee R. at Farad, CA		Truckee R. at Reno, NV		Steamboat Cr, at Steamboat, NV		Truckee R., below Derby Dam near Wadsworth, NV	
	(1895-96, 1909-78)		(1959-1978)		(1939-1978)		(1909-1978)		(1912-19, 30-35, 43-44, 46-78)		(1962-78)		(1918-78)	
	Ac-ft	%	Ac-ft	%	Ac-ft	%	Ac-ft	%	Ac-ft	%	Ac-ft	%	Ac-ft	%
Oct	13,300	8.1	496	3.0	5,820	4.7	24,100	4.4	16,200	3.6	451	4.6	3,720	1.6
Nov	11,700	7.1	714	4.3	4,580	3.7	23,800	4.4	22,500	5.0	375	3.8	5,760	2.4
Dec	12,500	7.6	1,030	6.1	6,520	5.3	30,400	5.6	31,500	7.0	421	4.3	15,400	6.4
Jan	13,200	8.0	1,650	9.8	5,190	4.2	33,300	6.1	36,200	8.1	787	8.0	20,000	8.3
Feb	14,800	9.0	1,460	8.7	6,330	5.1	33,500	6.1	36,400	8.1	816	8.3	24,000	10.0
Mar	13,700	8.3	2,080	12.4	9,160	7.4	44,700	8.2	45,900	10.2	935	9.6	27,600	11.5
Apr	8,630	5.2	3,460	20.6	22,300	18.0	76,800	14.1	67,200	15.0	857	8.8	40,000	16.7
May	8,120	4.9	3,260	19.4	32,400	26.1	105,000	19.2	86,700	19.4	1,300	13.3	55,900	23.3
Jun	12,900	7.8	1,480	8.8	18,300	14.8	75,000	13.8	58,000	12.9	1,780	18.2	33,700	14.1
Jul	18,000	10.9	436	2.6	6,520	5.3	39,400	7.2	21,000	4.7	972	9.9	6,830	2.8
Aug	20,600	12.5	346	2.1	4,270	3.4	31,700	5.8	13,800	3.1	646	6.6	3,520	1.5
Sep	17,500	10.6	360	2.2	2,540	2.0	27,600	5.1	13,000	2.9	445	4.6	3,260	1.4
Annual (Rounded)	165,000	100.0	16,800	100.0	124,000	100.0	545,000	100.0	448,000	100.0	9,790	100.0	240,000	100.0

9. Storm characteristics. - Precipitation in the headwater areas of the Truckee River Basin usually is associated with general storms which occur during the winter season of November through April. These storms originate over the Pacific Ocean and must cross the continuous barrier of the Sierra Nevada, which averages 8,000 feet in elevation, to reach these areas. The Truckee River headwater area is directly opposite the Donner Pass gap in the barrier, and occasionally air masses carry considerable precipitable moisture over the pass and cause heavy rainfall on the eastern slopes and on the Mt. Rose ridge east and north of Lake Tahoe. Storm periods last from 1 to 4 days. These storms usually produce general snowfall over the headwater areas, but some storms produce rain up to the maximum elevations of the basin.

The major general storms that have occurred over the Truckee River Basin since 1900 are those of February 1904, March 1907, January 1909, January 1914, January 1916, March 1928, December 1937, March 1940, January 1943, February 1945, November 1950, December 1950, December 1955, January-February 1963, and December 1964.

Local cloudbursts occur frequently during the summer. They usually occur in July and August when warm, moist air is more likely to reach this area of Nevada from the Gulf of California. These storms are characterized by high intensities over small areas and can produce large flood flows on the smaller tributary streams but do not have a major impact on flow in the Truckee River.

10. Flood characteristics. - Floods in the Truckee Basin can be divided into three distinct types: general rainfloods, cloudburst floods, and snowmelt floods.

General rainfloods, which occur during the period of November through April, result from general rain storms covering a large part of the basin and are characterized by high peak flows and short durations (3 to 6 days). A total volume of runoff from such floods is relatively small. A number of major general rainfloods have been experienced in the Truckee River Basin. Table 5 provides data on some of the larger floods at Reno.

TABLE 5
TRUCKEE RIVER AT RENO - HISTORICAL RAINFLOODS

Date	Peak Flow (cfs)	Max 1-Day Mean Flow (cfs)	Max 3-Day Volume (ac-ft)
18 Mar 07	18,500	14,600	68,400
16 Jan 09	10,100	8,540	43,600
26 Mar 28	18,800*	-	66,900*
11 Dec 37	17,000*	-	53,100*
21 Nov 50	19,900	14,100	55,300
4 Dec 50	11,700	6,580	30,600
23 Dec 55	20,800	16,200	67,400
1 Feb 63	18,400	11,500	47,700
23 Dec 64	11,300	9,400	44,600

*Estimated from records at other stations.

Snowmelt floods result from the melting of the snow-pack during the late spring and early summer (April through July) and have relatively large volumes and long durations. The distribution of runoff during the flood period is dependent on the ripeness of the snow and the variation in air temperatures. Generally the highest rates of flow occur in May and June. Snowmelt floods are essentially non-damaging in the Truckee Meadows area

existing conditions of upstream regulation. Data on several snowmelt floods are tabulated below.

TABLE 6
TRUCKEE RIVER AT RENO - HISTORICAL SNOWMELT FLOODS

Date	Peak Flow (cfs)	Max 1-Day Mean Flow (cfs)	Max 3-Day Volume (ac-ft)	April-July Volume (ac-ft)	Annual Volume (ac-ft)
7 May 06	-	6,600*	-	740,000*	-
14 Apr 07	-	7,200*	-	841,000	1,372,500
26 Apr 11	-	6,060	33,300	743,000	1,020,000
15 May 38	-	7,000*	-	652,000*	-
3 May 52	7,950	7,630	42,800	821,000	1,231,000
20 May 58	6,090	5,750	33,700	591,000	794,500
22 May 67	6,800	6,200	33,200	576,200	829,800

*Estimated from records at other stations.

Cloudburst floods are characterized by very high peak flows of short duration and low volume. These floods occur during the summertime, can carry large amounts of debris and sediment, and can cause considerable damage on the smaller tributaries. Data on several cloudburst floods are tabulated below.

TABLE 7

HISTORICAL CLOUDBURST FLOODS

Stream	DA (sq. mi.)	Date	Peak Flow (cfs)	Max 1-Day Mean Flow (cfs)
Galena Creek near Steamboat	8.5	20 Jul 56	4,730	---
		15 Aug 65	3,670	250
Whites Creek near Steamboat	8.02	15 Aug 65	2,280	100

CHAPTER III
STORM AND FLOOD ANALYSIS

11. General. - For purposes of hydrologic analysis the Truckee River Basin has been subdivided as indicated on chart 7. These subdivisions were made at various stream gage locations and at the various lakes and reservoirs to facilitate analysis of past floods. The many small area subdivisions around Reno were made to facilitiate possible future studies of this urban area. Because of the large surface area and volume of Lake Tahoe, relative to its drainage area, runoff into the lake during rain-flood periods is completely regulated and releases are negligible. Accordingly, the area above Lake Tahoe was not considered in the analysis. The analysis was made by developing a mathematical model of the basin using the computer program "HEC-1, Flood Hydrograph Package," as modified by the Sacramento District. The analysis includes a determination of base flows, loss rates, unit hydrographs, and flood routing parameters.

12. Floods analyzed. - The December 1955 and January-February 1963 storms and floods represent two of the largest general rain floods in the basin for which adequate flood hydrograph and precipitation data are available. Flood hydrographs and reconstitutions are shown on Galena and Whites Creeks. An analysis of these events was not possible because flood hydrographs and adequate precipitation data are not available.

13. Storm precipitation. - Basin precipitation for the 1955 and 1963 storms was determined from the isohyetal maps shown on charts 10 and 11. These maps were prepared from available precipitation data at the stations indicated on the charts. In areas where precipitation data was missing the isohyetal lines were patterned after the normal annual precipitation isohyetals. Time

distribution of precipitation was based on the records at one or more of the recording stations.

14. Snow effects.

a. December 1955. - Available data indicated that a substantial snowpack existed over the upper elevations of the Truckee River Basin prior to the December 1955 storm. Snow depths varied from zero at the 6,000 foot elevation to around 100 inches at the 9-10,000 foot elevation. Potential snowmelt rates were computed for each 1,000 foot elevation band by use of the melt equation for rain-on-snow conditions and partly forested areas given in EM 1110-2-1406. Temperatures were based on the record at the Truckee Ranger Station and a lapse rate of 3° F. per 1,000 feet. Wind data was based on the records at Sacramento since no other data was available. Winds used were those actually observed at Sacramento, reduced by 25 percent to approximate average conditions on the mountain slopes since Sacramento has an open exposure, and adjusted for elevation using figure 5-27 of "Hydrometeorological Report No. 36", dated October 1961.

The influence of the snowpack on runoff was determined using a computational procedure developed by the Bureau of Reclamation and described in Engineering Monograph No. 35, "Effect of Snow Compaction on Runoff from Rain on Snow", dated June 1966. The procedure is basically a water-budget analysis which accounts for the water in the snowpack until it is released in drainage. It uses the concept of "threshold density" and recognizes the compaction (shrinkage) of the snowpack as water is added. "Threshold density," defined as the density of the snowpack at which compaction ceases

and drainage from the pack begins, was assumed to be 40 percent. This procedure is similar to that presented in EM 1110-2-1460. The primary difference is that the EM procedures assumes that the initial snowpack is "ripe" (at "threshold density") over the entire basin whereas the USBR procedure allows the adoption of an initial snowpack with densities varying with elevation. The assumption of a "ripe" pack throughout the basin would not be realistic for the Truckee River since pack densities are known to vary with elevation.

Total available water was computed for each 1,000 foot elevation band using the above procedures. The area above 8,000 feet was non-contributiong.

b. January-Feburary 1963. - Available data indicates that the snow cover prior to the 1963 flood was substantially less than existed prior to the 1955 flood and that snowmelt apparently did not contribute significant amounts to runoff. Accordingly, a snowmelt analysis was not made. Based on available temperature data it was determined that rain fell up to an elevation of about 9,000 feet. This elevation was used to determine contributing areas for the flood reconstitutions.

15. Baseflow. - Baseflow was separated from the total runoff hydrographs as indicated on charts 8 and 9. Baseflow adopted for standard project and probable maximum general rain flood computations was slightly higher than observed historically to account for wetter antecedent conditions. Baseflow for cloudburst standard project and probable maximum flood computations for the tributary streams around Reno was assumed to equal a normal summertime flow on these streams since these types of storms occur during the summer.

16. Loss rates. - Loss rates developed during this study area based on the initial and constant infiltration loss concept. Higher losses were adopted for cloudburst floods because these events occur during the summertime when ground conditions are dry.

a. General rain floods. - Constant losses obtained from the flood reconstitutions ranged from a low of 0.05 inches per hour to a high of 0.23 inches per hour and average 0.15 inches per hour for the 1963 flood and 0.10 inches per hour for the 1955 flood. Based on these results a constant loss rate of 0.10 inches per hour was adopted for standard project and probable maximum flood computations. A slightly higher loss rate of 0.12 inches per hour was adopted for Spanish Springs Valley to account for additional ponding losses in this area. Zero initial losses were adopted for computation of standard project and probable maximum floods since antecedent conditions would be wet prior to the onset of these floods.

b. Cloudburst floods. - As discussed previously, a determination of loss rates using reconstituions of historical cloudburst floods was not possible due to a lack of hydrograph and precipitation data. A constant loss rate of 0.16 inches per hour and an initial loss of 0.30 inches was adopted. These losses are slightly higher than used for general rain floods since the cloudburst floods occur during the summertime when dryer ground conditions prevail. The adopted losses are consistent with those used in earlier studies.

17. Unit hydrographs. - Unit hydrographs for this study were developed using the modified Los Angeles District S-curve procedure presented in Technical Bulletin No. 5-550-3, "Flood Prediction Techniques," dated February 1957. This procedure utilizes a non-dimensional summation graph (S-cuve) in conjunction with a basin factor (n), which relates lag time to basin characteristics, to develop unit hydrographs. Adopted S-curves and lag relationships are shown on charts 12 and 13, respectively. Unit hydrograph parameters and ordinates are listed on tables 8, 9, 10, 11 and 12 (located at the end of text).

In a few cases the n values used for reconstitution of the 1955 and 1963 floods differ slightly. The values used for the 1963 flood were adopted for standard project flood computations since this flood is the largest on record in the basin. Unit hydrographs with higher peaks and shorter lag times than the 1963 unit hydrographs were developed for computation of probable maximum floods to account for the increased hydraulic efficiency of the basins during the occurrence of this type of event. These ajustments were accomplished by reducing the n values by 20 percent which produces a corresponding change in peak flows and lag times.

The S-curve used to establish unit hydrographs for the subareas above Lawton was developed from an analysis of the 1963 flood on Martis Creek, Alder Creek, Little Truckee River near Hobart Mills and Little Truckee River near Boca. The S-curves developed from the unit hydrographs for these areas were similar and the Martis Creek S-curve was adopted as being typical for the area.

Unit hydrographs for the subareas below Lawton, except Spanish Springs Valley, were developed using either the Truckee Meadows average valley S-curve (length = 743%), the Truckee Meadows average mountain S-curve for cloudburst events (length = 402%). The two mountain curves were developed for the Truckee Meadows Flood Plain Information Study (1969). The valley curve is identical to the Los Angeles S-curve used by the Los Angeles District and was used in the Truckee Meadows area for the flat valley areas.

The unit hydrograph developed for Spanish Springs Valley in the Truckee Meadows F.P.I. study used the Clark unit hydrograph technique. The unit hydrograph reflected Clark coefficients of T_c = 6.0 hours and R = 6.0 hours. A revised unit hydrograph for Spanish Springs Valley was developed fro the current study because the drainage area has been revised from that used in the FPI study to account for non-contributing areas. The revised unit hydrograph was developed from an S-curve prepared using the original unit hydrograph from the FPI study. The S-curve is shown on chart 12.

18. Flood routings. - The Truckee River and its tributaries, with the exception of the Truckee Meadows area, are mountainous streams where flows are confined to narrow canyon channels. Channel storage during large floods is small and does not significantly attenuate peak flows. Accordingly, flood routings for the Truckee River basin were accomplished using Muskingum coefficients for most routing reaches supplemented by Modified-Puls routings where storage has a considerable influence on downstream flows. A routing schematic with adopted routing coefficients is shown on chart 14. These coefficients were verified by reconstitution of the 1955 and 1963 floods. Modified-Puls routings and additional refinements are discussed below.

a. Six storage-discharge relationships were developed for Truckee Meadows to represent the differing channel and storage conditions in the Meadows. These relationships were developed using streamflow information at the Vista gage, calculated water surface profiles, historic high water marks in the Meadows and computed storage volumes from available topographic maps. The relationships for 1955 and 1963 conditions are shown on chart 15. The difference between 1955 and 1963 curves represents the channel enlargement work completed in 1963. Storage-discharge relationships for present (1980) conditions and future (1990) conditions were developed taking into account the effects of the Interstate 80 freeway and the decreased storage in the Meadows due to the present and projected development in the area. Interstate 80 acts as a barrier and prevents significant amounts of water from ponding on the north side of the freeway except during high volume runoff periods. Accordingly, the area north of the freeway was included for general rain flood routings on the Truckee River (high volumes), but was excluded for routing of cloudburst and general rain floods originating in the Steamboat Creek watershed. The standard project flood hyrographs presented in this report represent routings under 1990 conditions. Peak flows for these floods are 4 to 5 percent lower than routed under 1980 conditions.

b. Flows were routed through Independence and Donner Lakes, and Upper Peavine, Lower Peavine, East Wash, and West Wash Reservoirs using storage-discharge relationships furnished by the operating agencies of these facilities or developed by the Sacramento District using available spillway and reservoir capacity data. Storage-discharge relationships are shown on chart 15.

c. Regulated condition routings through Boca, Stampede, Prosser, and Martis Creek Reservoirs reflect the flood control operating criteria for these projects as specified in the "Master Report on Reservoir Regulation for Flood Control-Truckee River Reservoirs," dated December 1971.

d. Storage-discharge relationships were developed for routing of Steamboat Creek flows from index point 40 to the Huffacker Hills damsite. These relationships were developed from water surface profiles prepared for the June 1972 Flood Plain Information Study on Steamboat Creek. Storage-discharge relationships are shown on chart 15.

e. A storage-discharge relationship was developed for routing Dry Creek and Evans Creek from index point 64 to index point 70. This relationship was developed from backwater computations and flooded area maps prepared by Tudor Engineering Company for flood insurance studies. The storage discharge relationship is shown on chart 15.

f. The Truckee River channel and overbank capacities through Reno are limited. When these capacities are exceeded, water leaves the overbank areas and flows in a southeasterly direction, eventually combining with other runoff in the Truckee Meadows area. Division of flow relationships for determining overflows were estimated from water surface profile computations through the Reno area. These relationships are shown on chart 16. Overflows were routed separately using the Muskingum coefficients shown on chart 14.

g. A storage-discharge relationship was developed for the Highway 40 bridge at Wadsworth, since it is somewhat restrictive at the higher flows. This relationship is shown on chart 15.

h. Stream gaging records indicate that channel losses occur between Wadsworth and Nixon exceed about 10,000 cfs. In order to simulate these losses the relationship shown on chart 17 was developed and verified by reconstitution of the 1963 flood hydrograph and the 1955 peak flow at Nixon. The upper portion of this curve was estimated since historical flows at Nixon have not exceeded about 14,000 cfs (1955 and 1963 floods). This estimate was based on the following reasoning. Channel losses can probably be attributed to losses due to depression storage in overbank areas and to percolation losses to the Dodge Flat ground water basin, located between Wadsworth and Pyramid Lake. Depression losses are satisfied during the initial phases of a flood when channel capacities are exceeded and water can flow to and fill overbank storage areas. Once these areas are filled further losses to this source due to higher flows are greatly reduced. Percolation losses are a function of area flooded and head. Since the Truckee River flood plain between Wadsworth and Nixon is confined to a relatively narrow band the flooded area does not increase significantly with large increases in flow. Accordingly, losses to percolation will not increase by large amounts once the flood plain is covered with water. In view of the above, channel losses at the higher flows were increased only a small amount above those that occur at the lower flows.

CHAPTER IV
LAND USE

19. Land use. - Hydrologic studies in this report were developed for both present land use conditions (yr-1980) and estimated future land use conditions (yr-1990). In the Reno area land use changes may have some impact on runoff. In the other portions of the basin land uses are not expected to change signficantly and, accordingly, will have no impact on runoff.

Present and future land use conditions in the Reno area are presented on charts 18 and 19, respectively. These charts were developed from a base map prepared by the Nevada State Highway Department. Land use projections are based on those prepared by the Washoe County Regional Planning Commission (1978 Preliminary General Plan) and have been updated by this office to reflect current conditions and expected future trends.

The effects of the land use changes on runoff were accounted for by lowering loss rates in proportion to the imperviousness of the subareas. The following impervious factors were used for the various land use classifications.

TABLE 13
IMPERVIOUS FACTORS

Land Use	Percent Imperviousness
Forest and grazing areas	5
Agricultural	10
Residential	35
Commercial	60
Industrial	90

Runoff calculations using the above data indicated that land use changes have a negligible effect on peak flows at the points of interest. This results from the fact that the increase in urbanized area, when compared to the total drainage area above the points of interest, is very small. Accordingly, peak flow frequency curves presented both existing and future land use conditions.

Rapid development in the Truckee Meadows area has decreased the amount of space available in the Meadows for the storage of flood waters. This was accounted for as discussed in the preceding chapter.

CHAPTER V
FLOW FREQUENCY ANALYSIS

20. General. - Rainflood flow-frequency curves required for evaluation of possible flood control projects in the Reno area were developed for the following index points.

TABLE 14
LOCATION OF FLOW-FREQUENCY CURVES

Index Point No.	Description	Drainage Area (sq. mi.)	Curves
3460	Truckee River at Farad (USGS (#3460)	426 1/	Peak and Volume
600	Truckee River at Reno (USGS #3480)	561 1/	Peak and Volume
700	Truckee River nr Vista (USGS #3500)	819 2/	Peak and Volume
720	Truckee River below Derby Dam (USGS #3516)	1060 2/	Peak and Volume
740	Truckee River nr Nixon (USGS #3517)	1205 2/	Peak and Volume
30	Steamboat Creek at Steamboat (USGS #3493)	39.3 3/	Peak and Volume
60	Steamboat Creek at Huffacker Hills Damsite	110.4 3/	Peak
84	Steamboat Creek at Mouth	162.3 3/	Peak
20	Galena Creek nr Steamboat (USGS #3489)	8.5	Peak
505	Hunter Creek nr Reno (USGS #3476)	11.5	Peak
44	Whites Creek at Steamboat Ditch	14.6	Peak
66	Evans Creek at Steamboat Ditch	8.4	Peak
622	Dry Creek at Steamboat Ditch	3.6	Peak
64	Dry Creek at Highway 395	14.8	Peak
48	Thomas Creek at Steamboat Ditch	11.4	Peak
70	Boynton Slough	41.0	Peak
620	North Truckee Drain at Foothill Line	58.9 4/	Peak

1/ Contributing area below Lake Tahoe.
2/ Contributing area below Lake Tahoe and Washoe Lake.
3/ Contributing area below Washoe Lake.
4/ Contributing area.

Two peak flow frequency curves are presented for the Truckee River index points and represent unregulated and regulated conditions of water resource development. Unregulated conditions refers to a runoff regime without Boca, Stampede, Prosser, and Martis Creek Reservoirs but does include the effects of Lake Tahoe, Independence Lake, and Donner Lake. Regulated conditions includes the effects of Boca, Stampede, Prosser, and Martis Creek Reservoirs.

21. Truckee River. -

a. Unregulated conditions. - The period October through March was selected for analysis of rainfloods. Flows below Derby Dam have been impaired by diversions to the Truckee Canal since 1916. Further impairment of flows occurred when Boca, Prosser, Stampede, and Martis Creek Reservoirs were completed in 1938, 1963, 1969, and 1972, respectively. Accordingly, adjustments to the recorded flows are required to obtain a uniform unregulated flow record. Adjustments to account for Truckee Canal diversions were made by adding the daily diversions to the recorded daily flows at the gages below Derby Dam. Adjustments to account for operation of the various reservoirs were made by routing the daily changes in storage at the reservoirs to the downsteam gages and adding the routed changes to the recorded daily flows at the gages. Very few estimates of unregulated condition peak flows are available. Those estimates that are available are based on rainfall-runoff studies. Flows are listed on table 15 (located at the end of text).

The unregulated condition flows at the Truckee River gages were extended by multiple correlation with each other and with the longer record of the Truckee River at the Farad gage. The correlations were made using the HEC "Regional Frequency Computation" computer program. The missing flows estimated by this program include an ajustment for the natural variance in the data. Correlation coefficients are tabulated below.

Table 16
CORRELATION COEFFICIENTS - TRUCKEE RIVER

Station	Correlation Coefficients (with Farad gage) 1-day	3-day	7-day	15-day	30-day
Truckee River at Reno	.98	.99	.99	.99	.98
Truckee River at Vista	.96	.98	.98	.97	.97
Truckee River below Derby Dam	.94	.95	.96	.96	.96
Truckee River near Nixon	.98	.98	.97	.97	.98

The adopted unregulated condition flow frequency curves are shown on chart 20. Computed and adopted statistics are listed on table 15 (located at the end of text). Adopted means are based on the extended record. Adopted standard deviations and skews have been smoothed considerably to fit the historical data and give consistent volume-duration relationships. The standard deviations and skews based on the extended record were not used because the resulting curves did not fit the longer duration data. The curves include the expected probability adjustment for the indicated number of equivalent years of record.

A statistical analysis of peak flows was not possible because very few unregulated condition peak flow estimates are available. Accordingly, the adopted peak flow-frequency curves are graphical curves. The adopted curves for Farad, Reno, and Vista are identical to those presented in the December

1971 Truckee River "Master Report on Reservoir Regulation for Flood Control." The same curves were adopted for this study because the current analysis does not indicate a significant change from the earlier work. The adopted peak flow-frequency curves for below Derby Dam and Nixon were drawn by keeping the relationship between the peak and 1-day curves approximately the same as at Vista. The adopted peak curves are consistent with the 1-day curves, the historical data, and the computed standard project floods.

b. Regulated conditions. - Frequency curves for regulated conditions were based on records of historical events, appropriately adjusted for the effects of reservoirs completed since the event, and routings of both historic and hypothetical floods. All of the adjustments and routings were made to reflect reseservoir operation in accordance with current criteria and regulations.

Historic records were adjusted based on the fact that for any given event, the regulated flow at Reno could be no less than local flows downstream of the reservoir plus reservoir spill. Since none of the historic events were large enough to cause spill, the regulated flow at Reno would result from the uncontrolled locals. Uncontrolled locals were estimated as a percentage of the corresponding unregulated flow at Reno. Percentages were based on an evaluation of historic events, drainage areas, and normal annual precipitation relationships.

The four largest historical events (Nov-Dec 1950, Dec 1955, Jan-Feb 1963, and Dec 1964) were analyzed in more detail by estimating bi-hourly reservoir inflows and local flows below the reservoirs and routing these flows under regulated conditions. Runoff for the 1955 event was identical

with that developed for the storm and flood analyis described in Chapter III. Runoff for the remaining events were developed directly from streamflow records. Reservoir inflows were estimated from outflow and storage records or by correlation with other sites. Outflows from the reservoirs were routed to Reno and subtracted from the observed flows there to obtain the uncontrolled local. Local runoff below Reno was estimated from consideration of observed flows, drainage area, and precipitation patterns.

Regulated condition flows for rare events were determined by routing the standard project flood (SPF) and the 500, 100, and 50 year hypothetical floods through the reservoir system. A 20-day standard project flood series, determined as described in paragraph 27, was used for the routings instead of a single 5-day flood wave because it was found that total inflow volume as critical in determining the regulated condition downstream flows. This is attributed to the limited channel capacities and small reservoir outlet capacities in comparison to inflows. The 500, 100, and 50 year events were patterned after the SPF series. Flows of these flows are consistent with volume-duration relationships at Reno. Some adjustments were required for the one and three day durations to avoid unreasonable distortion of the hydrographs.

The following conditions and assumptions were used for all regulated condition routings:

a. All reservoirs were assumed to be at the bottom of flood control pool at the beginning of the event.

b. The error of forecasting local was assumed to be +25%.

c. Routing criteria were consistent with the rainfall-runoff models described in Chapter III.

d. Releases from the reservoirs included outlet works discharges when reservoir storage was above gross pool.

e. No channel efficiency contingencies were used since the releases computed by the simulation model during recession resulted in an effective channel flow which caried from 70-80% of channel capacity.

Regulated condition frequency curves were drawn from the adjusted and routed flows with plotting positions at all index points based on the frequency of the corresponding unregulated flow at Reno. The curves are shown on chart 21.

22. Truckee Meadows tributaries. -

a. Gated locations. - Flow frequency curves for Steamboat Creek, Galena Creek and Hunter Creek at the stream gage locations were prepared from an analysis of the stream flow record. These frequency curves were used as the basis for developing flow-frequency relationships for ungaged streams in the area. This area is subject to both winter general rain floods and summertime cloudburst floods. There is insufficient data to analyze each type event separately; accordingly, an all event analysis was made using the annual maximum flows regardless of their origin.

Computed and adopted statistical parameters at each of the stations are listed in the following table. As indicated, the adopted means to equal to the computed means; the adopted standard deviations are based primarily on the computed standard deviations but have been rounded and smoothed somewhat to give consistent volume-duration relationships; the adopted skews have been substantially rounded and smoothed. The curves are shown on charts 22, 23, and 24 and are consistent with the historical data. The expected probability adjustment is based on the number of years of record at each stations.

TABLE 17

STATISTICAL PARAMETERS FOR FLOW
FREQUENCY CURVES - STEAMBOAT, GALENA AND HUNTER CREEKS

		Steamboat Creek at Steamboat Contrib DA = 39.3 square miles (17-Years Record)		Galena Creek nr Steamboat DA = 8.5 square miles (17-Years Record)		Hunter Creek nr Reno DA = 11.5 square miles (12-Years Record)	
Flow Duration	Paramater (Log Units)	Computed	Adopted	Computed	Adopted	Computed	Adopted
Peak	Mean	2.163	2.163	2.057	2.057	1.799	1.799
	Std dev	.434	.46	.517	.46	.454	.46
	Skew	+.564	+.6	+1.724	+.6	+1.728	+.6
1-Day	Mean	1.798	1.798				
	Std dev	.420	.42				
	Skew	+.582	+.6				
3-Day	Mean	1.618	1.618				
	Std dev	.415	.40				
	Skew	+.552	+.5				
7-Day	Mean	1.479	1.479				
	Std dev	.385	.38				
	Skew	+.263	+.4				
15-Day	Mean	1.348	1.348				
	Std dev	.363	.37				
	Skew	+.067	+.3				
30-Day	Mean	1.229	1.229				
	Std dev	.349	.35				
	Skew	+.235	+.2				

b. Ungaged locations. -

(1) Evans, Dry, Thomas, and Whites Creeks. - Peak flow frequency curves were prepared for each of these creeks at Steamboat Ditch and for Dry Creek at Highway 395. All of these streams drain the eastern slopes of Mt. Rose and are similar in size, slopes, location, and exposure to the gaged streams of Hunter, Galena, and Steamboat Creeks. Accordingly, it was assumed that the shape of the peak flow-frequency curves for these ungaged locations would be similar to frequency curves for the gaged streams. The adopted curves, shown on chart 26, were based on ratios of the standard project flood. Ratios used are averages of ratios determined from the Hunter, Galena, and Steamboat curves. Ratios are tabulated below.

Flood	Ratios of SPF
1000 Yr	4.31
500 yr	2.06
SPF	1.00
200 yr	.84
100 yr	.45
50 yr	.24
20 yr	.11
10 yr	.06

(2) Steamboat Creek and Boynton Slough. - Peak flow-frequency curves were prepared for Steamboat Creek at Huffacker Hills damsite and at the mouth and for Boynton Slough below Dry Creek. Flows at these locations are affected by routings across Truckee Meadows. Accordingly, the procedures used in subparagraph (1) were not used because the storage effect of the Meadows is not reflected in the frequency curves at the gaged locations.

Both general rain and cloudburst events were analyzed using rainfall-runoff computations and the resulting flow-frequency curves were combined statistically to produce an all events curve. The curves are shown on charts 25 and 27. The general rain curve was prepared using ratios of the standard project flood. Ratios were developed from the 1-day flow frequency curve for the Steamboat Creek near Steamboat gage. The cloudburst curve was prepared using ratios of standard project cloudburst storm precipitation to develop various frequency cloudburst floods. Ratios were obtained from the Reno 3-hour precipitation frequency curve (chart 29). The combined curves were checked by developing a flow-frequency curve for Steamboat Creek at the gage using the above procedure and comparing it to the adopted curve at the gage. This check indicated the combined curves are reasonable.

(3) North Truckee Drain. - The area drained by North Truckee Drain (Spanish Springs Valley) is not typical of Steamboat Creek and its tributaries. Accordingly, the analysis of streamflow records on Steamboat Creek cannot be applied to North Truckee Drain. The area consists of many small streams that drain the foothill areas surrounding the valley. These streams flow out onto the flat valley floor where there are no defined stream channels other than North Truckee Drain at the lower end of the valley. Flooding from North Truckee Drain does not occur frequently. For example, Tudor Engineering Company reported that a local rancher who has lived in the area for 32 years stated that the drain had overflowed Spanish Springs Road (located at the lower end of Spanish Springs Valley) only twice in that period. Estimates of this flow by Tudor was about 270 cfs.

Recognizing the characteristics of the area, a peak flow-frequency curve for the area was developed using rainfall-runoff computations for the upper end of the curve and the historical experience in the area for the lower end of the curve. The estimated frequency curve is shown on chart 28. The upper end of the curve was drawn using the computed 100-year and 500-year (standard project) general rain floods. Standard project storms and floods are discussed in Chapter VI. The 100-year storm amount was determined using a 3-day precipitation frequency curve for Reno (chart 30). A cloudburst flood was not developed because it was reasoned that this type of event probably would not contribute significant amounts of runoff at the lower end of the valley due to the fact that the low volume in these types of floods would be lost crossing the valley floor. The resulting curve is reasonably consistent with flows developed for flood insurance studies.

CHAPTER VI
STANDARD PROJECT FLOODS

23. General. - Standard project floods (SPF) were computed for the Truckee River and for the Truckee Meadows tributaries. Both general rain and cloudburst events were analyzed. The general rain event produces the highest peak flows on the Truckee River while the cloudburst event produces the highest peak flows on the Truckee Meadows tributaries. The general rain event was adopted for standard project flood computation on North Truckee Drain (Spanish Springs Valley) because, as previously stated, the low volume of a cloudburst flood would essentially be lost as it flows across the valley floor.

24. Standard project storm. -

a. General rain. - Standard project storm (SPS) amounts equal to 60 percent of probable maximum precipitation were adopted. Probable maximum precipitation (PMP) amounts were determined using Hydrometeorological Report No. 49, "Probable Maximum Precipitation, Colorado and Great Basin Drainages," dated September 1977. The December storm was used since it produces the highest precipitation over the basin.

(1) Truckee River basin. - The Truckee River storm was centered over the basin above Lawton since this area is the major contributor to runoff at downstream points. Concurrent storms were computed for the areas between Lawton and Vista and between Vista and Nixon. Adopted SPS amounts and a comparison with historical storms are tabulated below.

TABLE 18

GENERAL RAIN STANDARD PROJECT AND
HISTORICAL STORM AMOUNTS

Area	Storm Amounts (inches) SPS (72-hr)	21-23 Dec 1955	30 Jan-1 Feb 1963
Above Lawton	11.5	9.8	9.5
Lawton to Vista	6.1	5.0	5.4
Vista to Nixon	4.3	2 ±	1.8

(2) Steamboat Creek and Spanish Springs Valley. - Standard project storms were centered over Steamboat Creek above its mouth and over Spanish Springs Valley above index point 620. Storm amounts (72 hour duration) for the two areas are 7.1 and 6.2 inches, respectively.

b. Cloudburst. - Cloudburst SPS amounts (3-hour duration) were developed using 35 percent of the maximum 3-hour cloudburst probable maximum precipitation. As indicated on chart 29, the SPS has an exceedance frequency of about 0.2 per hundred years. Probable maximum precipitation was determined from Hydrometeorological Report No. 49. Several storm centerings were used to develop standard project floods at the various index points. Centerings and storm amounts are tabulated on table 19.

TABLE 19
CLOUDBURST STANDARD PROJECT STORM AMOUNTS

Location	Index Point No.	SPS Centering and Storm Amount (3-Hr Duration) Specific Over Subarea	SPD (in)	Concurrent Over Subarea	SPS (in)
Galena Creek nr Steamboat	20	201, 20	3.54	No Concurrent	-----
Whites Creek at Steamboat Ditch	44	42	3.59	44	3.01
Thomas Creek at Steamboat Ditch	48	48	3.47	No Concurrent	-----
Dry Creek, at Steamboat Ditch and at Hwy 395	622	621, 622, 623, 624	3.50	64	2.92
Boynton Slough	70	62, 64, 66, 68	3,06	60, 72, 74, 76, 78	2.47
Evans Creek at Steamboat Ditch	66	66	3.54	No Concurrent	-----
Steamboat Creek at Steamboat	30	15, 201, 20, 25, 42, 44, 48	2.80	30, 35, 40 46, 50, 60	1.84
Steamboat Creek at Huffacker Hills	60	15, 201 20, 25, 42, 44, 48	2.80	30, 35, 40, 46, 50, 60	1.84
Steamboat Creek at mouth	84	15, 201, 20, 25, 30, 35, 40, 42, 44, 48, 62, 66	2.35	46, 50, 60 64, 68, 70 72, 74, 76, 78, 80, 82, 84	1.66 1.36

25. Snow effects. - A snowpack was assumed to exist over the Truckee River Basin prior to the occurrence of the standard project general rain storm because there is normally a snowpack present on the basin in the wintertime. There would be no snowpack prior to a cloudburst storm because these events occur during the summertime.

An initial snowpack over the area above Lawton, varying from zero at the 4,400 foot elevation to about 140 inches at the 9,000 foot elevation, was adopted for standard project general rain flood computations. This pack is similar to that which existed over the basin prior to the December 1955 storm and flood except that the lower edge has been extended to the 4,400 foot elevation. The pack is also similar to that obtained from the Sacramento Districts' criteria presented in "Standard Project Criteria for General and Local Storms, Sacramento-San Joaquin Valleys, California," dated April 1971 and used in earlier studies of the Truckee River Basin. A snowpack equal to 50 percent of the pack above Lawton was adopted for the area between Lawton and Vista while a pack equal to 25 precent of the pack above Lawton was adopted fro the area below Vista. These percentages are based on a comparison of average 1 February snow depth measurements in the basin taken from "Summary of Snow Survey Measurements for Nevada," Soil Conservation Service, 1910-67 and 1968-72. Adopted snowpacks are shown on chart 31.

Potential snowmelt rates were computed for each 1,000 foot elevation band by use of the melt equation for rain-on-snow conditions and partly forested areas given in EM 1110-2-1406. Precipitation distribution, wind, and temperature data for use on this equation were those observed during the January-February 1963 storm. This event was used as a pattern since it is the largest flood of record in the basin. Storm amounts were distributed to the various elevation zones in proportion to the normal annual precipitation of the zones. Precipitation was assumed to fall as rain when temperatures were above 32°.

The influence of the snowpack on runoff was determined as discussed in paragraph 14a. Table 20 summarizes the rain on snow computations for the Truckee River Standard Project Flood.

Band excess amounts were distributed to the various subareas in proportion to the percentage of each subarea in each elevation zone. The entire area below 9,000 feet was considered to be contributing even though the snowmelt computations indicated that only the area below 8,000 feet would be contributing between Lake Tahoe and Vista. This assumption is conservative and does not introduce a signficant increase in runoff since the additional drainage area involved is only about 40 square miles.

26. Standard project floods - unregulated conditions. - Standard project floods for unregulated conditions were computed using the unit hydrograph, loss rate, base flow, flood routing and storm criteria discussed previously. These floods do not include the effects of Boca, Stampede, Prosser, and Martis Creek Reservoirs. Pertinent data on these floods are shown on Tables 21 and 22. Typical hydrographs are shown on charts 32 and 33.

TABLE 20

SUMMARY OF RAIN-ON-SNOW COMPUTATIONS - TRUCKEE RIVER SPF

LAKE TAHOE TO LAWTON

Elevation Band	Band Area (sq mi)	Band Exposure Constant	Antecedent Snow Cover Density (%)	Antecedent Snow Cover Depth (in)	Total Precip (in)	Total Snowmelt (in)	Total Excess Water (in)	Remaining Snow Cover Density (%)	Remaining Snow Cover Depth (in)
4600-5000	7.6	1.0	35.2	15.5	3.6	5.77	9.06	.0	.0
5000-6000	118.0	.8	28.4	27.3	7.9	5.57	12.05	40.0	9.01
6000-7000	234.0	.8	21.6	49.3	11.0	4.95	12.18	40.0	23.66
7000-8000	104.0	.5	16.2	78.4	14.0	1.29	5.46	40.0	53.10
8000-9000	39.6	.5	12.5	116.4	16.9	.0	.0	27.59	114.01
9000-10000	7.9	.5	10.3	157.4	17.8	.0	.0	18.26	186.29
10000-10800	.6	.5	10.0	176.5	19.0	.0	.0	11.17	328.15
LAWTON TO VISTA (areas North of Truckee River)									
4400-5000	80.6	1.0	37.3	5.5	3.4	2.07	5.45	0.0	0.0
5000-6000	44.7	1.0	28.4	13.5	5.2	4.17	9.03	0.0	0.0
6000-7000	8.8	.5	21.6	24.5	8.2	3.31	9.83	40.0	9.16
7000-8000	3.3	.5	16.2	39.5	12.4	2.93	10.93	40.0	19.67
8000-9000	5.0	.5	12.5	59.0	16.6	.72	4.28	40.0	49.25
9000-10000	1.2	.5	10.3	77.5	19.6	.0	.0	32.61	84.58

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TABLE 20 (Cont'd)

LAWTON TO VISTA (Areas South of Truckee River)

Elevation Band	Band Area (sq mi)	Band Exposure Constant	Antecedent Snow Cover Density (%)	Antecedent Snow Cover Depth (in)	Total Precip (in)	Total Snowmelt (in)	Total Excess Water (in)	Remaining Snow Cover Density (%)	Remaining Snow Cover Depth (in)
4400-5000	63.5	1.0	37.3	5.5	3.4	2.07	5.45	.0	.0
5000-6000	97.8	1.0	28.4	13.5	5.2	4.17	9.03	.0	.0
6000-7000	38.8	1.0	21.6	24.5	8.2	5.04	11.72	40.0	4.43
7000-8000	24.1	1.0	16.2	39.5	12.4	4.23	12.54	40.0	15.64
8000-9000	16.1	1.0	12.5	59.0	16.6	1.82	5.37	40.0	46.51
9000-10000	7.3	1.0	10.3	77.5	19.6	.0	.0	33.99	81.15
				VISTA TO NIXON					
3870-4000	7.5	1.0	0	.0	3.4	.0	3.4	.0	.0
4000-5000	201.5	1.0	38	2.0	3.7	.76	4.46	.0	.0
5000-6000	175.2	1.0	28.4	7.0	4.5	2.04	6.49	.0	.0
6000-7000	88.5	1.0	21.6	12.5	5.2	3.25	7.90	.0	.0
7000-8000	6.7	1.0	16.2	19.5	7.0	4.58	10.04	40.0	.3
8000-9000	.0	1.0	12.5	29.5	8.1	2.23	5.85	40.0	14.84

TABLE 21

GENERAL RAIN STANDARD PROJECT FLOODS
UNREGULATED CONDITIONS

Location	Contributing Drainage Area* (sq mi)	Total Drainage Area (sq mi)	Index Point	Peak Flow (cfs)	5-Day Volume (AF)
Truckee River at Farad (USGS #3460)	417.5	932	3,460	60,100	148,000
Truckee River at Reno (USGS #3480)	548	1,067	600	71,000	192,200
Truckee River at Vista (USGS #3500)	798	1,429	700	56,500	243,400
Truckee River below Derby Dam (USGS #3516)	1,039	1,670	720	56,300	245,800
Truckee River near Nixon (USGS #3517)	1,184	1,815	740	53,500	233,100
Streamboat Creek at Huffacker Hills Damsite	103.9	194	60	13,500	27,000
Steamboat Creek at Mouth	155.8	246	84	14,800	38,600
Spanish Spring Valley (North) Truckee Drain at foothill line)	58.9	78.5	620	2,500	4,640

*Does not include areas above Lake Tahoe and above Washoe Lake, non-contributing area in Spanish Springs Valley, and areas above 9,000 feet elevation.

TABLE 22

CLOUDBURST STANDARD PROJECT FLOODS

Location	Contributing Drainage Area* (sq mi)	Total Drainage Area (sq mi)	Index Point	Peak Flow (cfs)	Volume (acre-ft)	Duration (hrs)
Steamboat Creek at Steamboat (USGS #3493)	39.3	123	30	15,200	3,700	24
Steamboat Creek at Huffacker Hill Damsite	110.4	194	60	13,600	9,550	24
Steamboat Creek at Mouth	162.3	246	84	11,100	12,400	36
Galena Creek near Steamboat (USGS #3489)	8.5	8.5	20	6,000	1,310	12
Whites Creek at Steamboat Ditch	14.6	14.6	44	8,700	2,110	12
Evans Creek at Steamboat Ditch	8.4	8.4	66	4,900	1,310	12
Dry Creek at Steamboat Ditch	3.6	3.6	622	2,650	560	12
Dry Creek at Highway 395	14.8	14.8	64	10,900	2,160	12
Thomas Creek at Steamboat Ditch	11.4	11.4	48	5,600	1,730	12
Boynton Slough	41.0	41.0	70	14,000	4,970	12

27. Standard project flood series. - A 20-day standard project flood series for the Truckee River was developed for operation studies involving the upstream reservoirs. This series, as plotted on chart 34, was developed to be consistent with the volume-duration curves for the Truckee River at Reno. The 200-year volume was used for durations between 5 and 20 days. The series consists of four 5-day waves for volumes as indicated on Table 13. Each wave was patterned after the main wave.

28. Standard project floods - regulated conditions. - Regulated condition standard project floods were developed for the Truckee River by routing the unregulated condition SPF's through Boca, Stampede, Prosser, and Martis Creek Reservoirs. Routings through these reservoirs were made in accordance with regulations specified in the "Master Report on Reservoir Regulation for Flood Control - Truckee River Reservoirs," dated December 1971. Flood hydrographs are shown on chart 32. Pertinent data are shown on Table 24.

TABLE 23

TRUCKEE RIVER AT RENO
STANDARD PROJECT FLOOD SERIES

Duration (days)	Volume (cfs-days)	Time Order of Occurrence
5	96,900	3rd (main wave)
5	25,000	2nd
5	15,000	4th
5	12,000	1st

TABLE 24

GENERAL RAIN STANDARD PROJECT FLOODS
REGULATED CONDITIONS

Location	Index Point	Peak Flow (cfs)	5-Day Volume (AF)
Truckee River at Reno (USGS #3480)	600	40,000	121,000
Truckee River at Vista (USGS #3500)	700	37,000	170,000
Truckee River below Derby Dam (USGS #3516)	720	37,000	172,900
Truckee River near Nixon (USGS #3517)	740	34,300	163,200

CHAPTER VII
PROBABLE MAXIMUM FLOODS

29. General. - General rain and cloudburst probable maximum floods (PMF) were developed for Steamboat Creek at the Huffacker Hills damsite. Both types of floods were considered since it is not known which type of event would be critical for spillway design.

30. Probable maximum precipitation. - Probable maximum precipitation (PMP) for both the general rain (72-hour duration) and cloudburst (6-hour duration) storms was determined using Hydrometeorological Report No. 49, "Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages," dated September 1977.

a. General rain. - The December general rain storm was adopted for computation of the general rain PMP since it produces the highest precipitation. General rain PMP for a storm centered over the area above the damsite is 11.9 inches.

b. Cloudburst. - A cloudburst centered over the upper aeas of the basin was adopted for cloudburst PMF computations. This centering is identical to that used for computation of the standard project flood at the damsite. The storm amount for the upper areas (subareas 15, 201, 20, 25, 42, 44, and 48) is 8.0 inches while the concurrent amount for the lower areas (subareas 30, 35, 40, 46, 50 and 60) is 5.2 inches.

31. Snow effects (general rain flood). - A snowpack was assumed to exist over the basin above the Huffacker Hills damsite prior to the occurrence of the general rain PMF because there is normally a snowpack on the basin the winter-time. Since the PMF would most likely occur during the December - January period (December adopted for this study - see paragraph 30a) a review of maximum historic snow depths during this period was made to establish a reasonable snowpack. The snowpack on 1 February 1952 was found to be substantially larger than any other historic snowpack. This pack was adopted for PMF computations with the exception that it is somewhat deeper at the lower elevations. Snow densities were assumed to vary from 40 percent at the 5,000 foot elevations to 30 percent at the 10,000 foot elevation. These densities are essentially equivalent to the 1952 densities but are somewhat higher than normal snowpack densities for this time of year. The adopted pack is about twice as large and substantially more dense than the pack used for SPF computations. Snow depths and densities are shown on table 25. *

Potential snowmelt rates were computed for each 1,000 foot elevation band by use of the melt equation for rain-on-snow conditions and partly forested areas given in EM 1110-2-1406. Precipitation distribution, wind, and temperature data for use in this equation were based on criteria presented in Hydrometeorological Report No. 36, "Interim Report, Probable Maximum Precipitation in California," dated October 1961. Report No. 36 was used for wind and temperature data because Report No. 49 does not present this information. Use of Report No. 36 was informally discussed with representatives of the Hydrometeorological Branch of the National Weather Service and agreed upon as being applicable to the Steamboat Creek Basin.

*Revised June 1980

Storm amounts were distributed to the various elevation zones in proporation to the normal annual precipitation of the zones. Precipitation was assumed to fall as rain when temperatures were above 32°F.

The influence of the snowpack on runoff was determined as discussed in paragraph 14a. Table 25 summarizes the rain-on-snow computations. Band excess amounts were distributed to the various subareas in proportion to the percentage of each subarea in each elevation zone. The entire area was considered to be contributing even though the snowmelt computations indicate that the small area above 10,000 feet would be non-contributing. *

32. Probable maximum floods. - Probable maximum floods were computed using the unit hydrograph, loss rate, base flow, flood routing, and storm criteria discussed previously. Hydrographs are shown on chart 35. The cloudburst PMF has a peak flow of 94,000 cfs and a 24-hour volume of 34,100 acre-feet. The general rain PMF has a peak flow of 35,500 cfs and a 4-day volume of 67,500 AF. *

*Revised June 1980

TABLE 25

SUMMARY OF RAIN-ON-SNOW COMPUTATIONS - STEAMBOAT CREEK PMF

Elevation Band	Band Area (sq mi)	Band Exposure Constant	Antecedent Snow Cover Density (%)	Antecedent Snow Cover Depth (in)	Total Precip (in)	Total Snowmelt (in)	Total Excess Water (in)	Remaining Snow Cover Density (%)	Remaining Snow Cover Depth (in)
4415-5000	29.8	1.0	40	15.5	5.57	6.20	11.77	0	0
5000-6000	39.7	1.0	39	27.3	8.79	10.65	19.44	0	0
6000-7000	16.3	1.0	37	49.3	12.21	10.13	21.94	40	21.29
7000-8000	10.8	1.0	35	78.4	18.50	6.63	23.50	40	56.10
8000-9000	7.3	1.0	33	116.4	23.09	2.53	19.41	35.63	118.14
9000-10000	5.5	1.0	31	157.4	29.31	0	1.37	33.48	229.21
10000-10800	0.9	1.0	29	176.5	31.74	0	0	16.79	493.90

TABLE 8

UNIT HYDROGRAPH CHARACTERISTICS AND ORDINATES
DRAINAGE AREA BELOW 8,000 FEET, MSL, FOR DECEMBER 1955 FLOOD

SUBAREAS	15	20	25	30	35	40	42	44	46	48	50	60	62	64	66
CHARACTERISTICS															
D.A. (Sq. Mi.)	3.4	3.1	8.1	17.8	15.6	2.9	3.4	6.6	1.8	9.1	2.4	22.4	10.2	4.6	7.2
L (Mi.)	4.1	4.7	6.0	6.4	8.4	2.6	4.6	4.2	1.7	7.7	1.6	7.7	4.7	2.5	5.5
Lca (Mi.)	1.8	2.5	2.7	2.1	4.7	1.0	2.3	1.4	1.0	3.7	1.0	2.7	1.5	1.2	3.0
SLOPE (Ft./Mi.)	660.2	516.7	505.0	186.3	337.3	145.0	442.6	384.4	98.8	418.7	171.8	246.4	590.1	129.9	578.2
$LL_{ca}/S^{.5}$	0.29	0.51	0.74	0.99	2.13	0.23	0.51	0.29	0.18	1.40	0.12	1.32	0.29	0.27	0.70
$\bar{n}$	.075	.075	.075	.075	.075	.075	.075	.075	.07	.075	.07	.07	.075	.07	.075
LAG (Hours)	1.1	1.4	1.6	1.8	2.4	1.0	1.4	1.1	0.9	2.1	0.8	1.9	1.1	1.0	1.6
S-CURVE	1/	1/	1/	1/	1/	2/	1/	1/	2/	1/	2/	2/	1/	2/	1/

1/ Truckee Meadows average mountain - GR., 2/ Truckee Meadows average valley - GR/CB.

ONE HOUR UNIT HYDROGRAPH ORDINATES
(End of period flow in c.f.s.)

TIME PERIOD *(Hours)*	15	20	25	30	35	40	42	44	46	48	50	60	62	64	66
1	950	636	1363	2478	1240	856	696	1343	670	992	988	1554	2827	1361	1245
2	802	742	1886	3943	2764	608	815	1549	306	1867	345	6105	2376	976	1679
3	266	316	988	2386	2276	183	348	513	100	1298	116	2849	787	294	853
4	108	141	444	1119	1440	94	155	207	50	696	56	1311	318	151	383
5	38	66	241	631	801	56	73	73	28	381	26	784	112	89	204
6	24	28	118	350	502	33	30	46	12	238	5	534	70	54	98
7	19	18	55	181	339	16	20	36	2	139		383	55	26	47
8	13	15	42	97	213	3	16	25		77		283	38	5	36
9		12	35	80	131		13			44		219			30
10		7	29	68	76		8			37		166			26
11			23	58	58					32		121			19
12			5	48	51					28		82			0
13				22	45					25		44			
14					41					19		15			
15					37					6					
16					31										
17					21										
TOTAL	2220	1981	5229	11461	10066	1849	2174	4292	1168	5879	1536	14450	6583	2956	4620

NOTE:
Unit hydrographs for subareas 502-650, 68-84, and 700-760 are shown on Table 10.

UNIT HYDROGRAPH CH

DRAINAGE AREAS BELOW 8,00(

SUBAREAS	3380	3385	50	100	3394	3397	3399	3403
								C
Contributing D.A. (Sq. Mi.)	39.1	13.3	15.1	14.1	27.6	24.4	7.4	15.7
L (Mi.)	11.2	5.1	7.9	9.0	9.1	10.2	6.2	5.8
Lca (Mi.)	5.9	2.6	4.7	3.6	2.9	5.3	3.0	2.2
SLOPE (Ft./Mi.)	185.7	405.9	276.0	151.1	139.6	225.5	290.3	237.6
$LLca/S^{.5}$	4.85	0.66	1.95	2.64	2.24	3.60	1.10	0.83
$\bar{n}$	0.06	0.06	0.06	0.06	0.12	0.06	0.06	0.06
LAG (Hours)	2.6	1.2	1.9	2.1	3.9	2.4	1.5	1.4
S-CURVE								1

ONE HOUR L

(End of

TIME PERIOD *(Hours)*								
1	5060	3618	2832	2349	2157	3580	1696	3980
2	5047	2277	2320	2055	2753	3350	1215	2661
3	3791	1240	1549	1433	2268	2432	735	1524
4	2848	675	1035	1000	1872	1766	445	872
5	2141	368	691	698	1545	1283	269	500
6	1609	200	462	486	1275	931	163	286
7	1207	109	309	339	1053	676	98	164
8	908	59	206	237	869	491	59	94
9	682	30	137	165	717	356	36	54
10	512		92	115	591	258	22	24
11	384		61	80	488	188	11	
12	289		41	56	403	136		
13	217		27	39	333	99		
14	163		9	27	275	72		
15	123			19	226	53		
16	92			1	187	38		
17	69				154	26		
18	52				128			
19	37				105			
20					87			
21					71			
22					59			
23					49			
24					40			
25					33			
26					27			
27					23			
28					18			
29					4			
30								
31								
32								
33								
34								
35								
36								
37								
TOTAL	25231	8576	9771	9099	17810	15735	4749	10159

NOTE;

Unit hydrographs for subareas 502-650, 68-84, and 700-760 are shown on Table 10.

TABLE 8

UNIT HYDROGRAPH CHARACTERISTICS AND ORDINATES
DRAINAGE AREAS BELOW 8,000 FEET, MSL, FOR THE DEC 1955 FLOOD

100	3394	3397	3399	3403	3405	200	3420	3430	3435	3443	3444	3445	:
						CHARACTERISTICS							
14.1	27.6	24.4	7.4	15.7	2.7	8.3	32.4	5.8	10.1	70.5	8.2	25.5	
9.0	9.1	10.2	6.2	5.8	3.5	3.8	12.8	5.0	4.3	13.3	5.9	8.2	
3.6	2.9	5.3	3.0	2.2	1.4	1.4	7.8	2.5	1.6	3.6	3.9	2.5	
151.1	139.6	225.5	290.3	237.6	93.7	331.6	63.3	540.0	184.0	94.9	184.2	183.4	25
2.64	2.24	3.60	1.10	0.83	0.51	0.30	12.55	0.54	0.52	4.85	1.71	1.50	
0.06	0.12	0.06	0.06	0.06	0.06	0.06	0.08	0.06	0.06	0.06	0.06	0.06	
2.1	3.9	2.4	1.5	1.4	1.1	0.9	5.0	1.2	1.1	2.6	1.8	1.7	

TRUCKEE RIVER BASIN - MARTIS CREEK - MOUNTAIN

ONE HOUR UNIT HYDROGRAPH ORDINATES
(End of period flow in c.f.s.)

100	3394	3397	3399	3403	3405	200	3420	3430	3435	3443	3444	3445
2349	2157	3580	1696	3980	797	2865	1742	1681	2964	9127	1611	5260
2055	2753	3350	1215	2661	466	1412	2678	1000	1743	9104	1280	4056
1433	2268	2432	735	1524	238	620	2308	519	896	6839	837	2595
1000	1872	1766	445	872	122	272	1987	270	460	5138	548	1661
698	1545	1283	269	500	62	119	1711	140	236	3862	358	1062
486	1275	931	163	286	32	53	1473	73	121	2902	234	680
339	1053	676	98	164	16	16	1269	38	62	2178	153	434
237	869	491	59	94	8		1092	20	32	1638	100	278
165	717	356	36	54	1		941	3	3	1231	65	177
115	591	258	22	24			810			924	43	114
80	488	188	11				698			693	28	73
56	403	136					601			522	18	46
39	333	99					517			391	10	5
27	275	72					445			293		
19	226	53					384			222		
1	187	38					330			166		
	154	26					284			125		
	128						245			94		
	105						211			67		
	87						181					
	71						156					
	59						134					
	49						116					
	40						100					
	33						86					
	27						74					
	23						63					
	18						55					
	4						48					
							40					
							35					
							30					
							26					
							22					
							19					
							16					
							4					
9099	17810	15735	4749	10159	1742	5357	20931	3744	6517	45516	5285	16441

700-760 are shown on Table 10.

)RDINATES
'E DEC 1955 FLOOD

3430	3435	3443	3444	3445	300	3460	400	3473	500
5.8	10.1	70.5	8.2	25.5	2.3	21.8	29.3	13.6	27.6
5.0	4.3	13.3	5.9	8.2	1.6	11.1	8.7	3.4	9.9
2.5	1.6	3.6	3.9	2.5	0.8	5.2	2.4	1.2	3.6
540.0	184.0	94.9	184.2	183.4	259.5	165.8	244.0	400.0	239.4
0.54	0.52	4.85	1.71	1.50	0.09	4.53	1.32	0.20	2.27
0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
1.2	1.1	2.6	1.8	1.7	0.6	2.6	1.6	0.8	2.0

S CREEK - MOUNTAIN

1681	2964	9127	1611	5260	1061	2914	6316	5190	4881
1000	1743	9104	1280	4056	314	2864	4731	2228	4131
519	896	6839	837	2595	85	2134	2963	860	2820
270	460	5138	548	1661	23	1591	1856	332	1927
140	236	3862	358	1062	2	1187	1161	128	1315
73	121	2902	234	680		885	728	39	898
38	62	2178	153	434		659	455		613
20	32	1638	100	278		492	285		418
3	3	1231	65	177		367	178		286
		924	43	114		273	112		195
		693	28	73		204	70		133
		522	18	46		154	28		91
		391	10	5		113			62
		293				84			42
		222				63			7
		166				47			
		125				35			
		94				26			
		67				10			
3744	6517	45516	5285	16441	1485	14102	18883	8777	17819

T

UNIT HYDROGRAPH CHA

DRAINAGE AREAS BELOW 9,000 FEET, MSL, FOR THE

SUBAREAS	3380	3385	50	100	3394	3397	3399	3403
								CH
Contributing D.A. (Sq. Mi.)	46.0	14.6	17.6	14.1	40.0	27.4	7.4	15.7
L (Mi.)	11.4	5.5	8.1	9.0	10.2	10.3	6.2	5.8
Lca (Mi.)	6.3	2.9	4.4	3.6	2.9	6.0	3.0	2.2
SLOPE (Ft./Mi.)	270.2	449.1	318.5	151.1	179.4	301.0	290.3	237.6
$LLca/S^{.5}$	4.37	0.76	2.00	2.64	2.21	3.57	1.10	0.83
$\bar{n}$	0.06	0.06	0.06	0.06	0.12	0.06	0.06	0.06
LAG (Hours)	2.5	1.3	1.9	2.1	3.9	2.3	1.5	1.4
S-CURVE								TR
								ONE HOUR UNI (*End of pe*
TIME PERIOD (*Hours*)								
1	6227	3808	3263	2349	3145	4041	1696	3980
2	6073	2484	2687	2055	4002	3772	1215	2661
3	4510	1394	1801	1433	3295	2736	735	1524
4	3349	782	1208	1000	2717	1983	445	872
5	2489	439	809	698	2241	1439	269	500
6	1849	246	542	486	1847	1043	163	286
7	1371	138	364	339	1524	757	98	164
8	1020	78	243	237	1257	549	59	94
9	758	43	163	165	1037	398	36	54
10	561	11	109	115	854	288	22	24
11	417		73	80	704	209	11	
12	310		49	56	581	151		
13	230		33	39	479	110		
14	170		13	27	396	80		
15	127			19	325	58		
16	95			1	268	42		
17	70				221	27		
18	52				183			
19	10				150			
20					124			
21					102			
22					85			
23					70			
24					58			
25					48			
26					39			
27					32			
28					26			
29					3			
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
TOTAL	29688	9423	11357	9099	25813	17683	4749	10159

TABLE 9

UNIT HYDROGRAPH CHARACTERISTICS AND ORDINATES

,000 FEET, MSL, FOR THE STANDARD PROJECT GENERAL RAIN AND JAN-FEB 1963 FLOODS

394	3397	3399	3403	3405	200	3420	3430	3435	3443	3444	3445	300	3
					CHARACTERISTICS								
0.0	27.4	7.4	15.7	2.7	8.3	36.5	7.6	10.8	81.1	10.0	26.0	2.3	4
0.2	10.3	6.2	5.8	3.5	3.8	12.8	5.4	4.7	13.3	6.6	8.2	1.6	1.
2.9	6.0	3.0	2.2	1.4	1.4	7.6	2.6	1.7	4.2	4.8	2.5	0.8	
9.4	301.0	290.3	237.6	93.7	331.6	139.8	648.2	355.2	155.0	363.2	256.7	259.5	26
2.21	3.57	1.10	0.83	0.51	0.30	8.23	0.56	0.43	4.54	1.68	1.27	0.09	
0.12	0.06	0.06	0.06	0.06	0.06	0.10	0.06	0.06	0.06	0.06	0.06	0.06	
3.9	2.3	1.5	1.4	1.1	0.9	5.4	1.2	1.1	2.6	1.8	1.6	0.6	
					TRUCKEE RIVER BASIN - MARTIS CREEK - MOUNTAIN								
				ONE HOUR UNIT HYDROGRAPH ORDINATES (End of period flow in c.f.s.)									
145	4041	1696	3980	797′	2865	1766	2195	3365	10803	1979	5699	1061	6
002	3772	1215	2661	466	1412	2865	1315	1864	10619	1567	4226	314	6
295	2736	735	1524	238	620	2496	687	909	7918	1022	2626	85	4
717	1983	445	872	122	272	2168	359	443	5905	667	1632	23	3
241	1439	269	500	62	119	1884	187	216	4406	434	1014	2	2
847	1043	163	286	32	53	1637	98	105	3286	284	630		1
524	757	98	164	16	16	1423	51	51	2448	185	391		1
257	549	59	94	8		1236	27	16	1828	120	243		1
037	398	36	54	1		1074	6		1364	78	151		
854	288	22	24			934			1014	51	94		
704	209	11				811			756	33	58		
581	151					705			565	22	16		
479	110					612			420	10			
396	80					532			313				
325	58					462			234				
268	42					402			175				
221	27					349			131				
183						303			97				
150						264			37				
124						229							
102						198							
85						173							
70						150							
58						130							
48						114							
39						98							
32						85							
26						74							
3						64							
						56							
						49							
						42							
						37							
						32							
						28							
						24							
						21							
						18							
						9							
813	17683	4749	10159	1742	5357	23554	4925	6969	52319	6452	16780	1485	31

NATES
RAL RAIN AND JAN-FEB 1963 FLOODS

0	3435	3443	3444	3445	300	3460	400	3473	500
5	10.8	81.1	10.0	26.0	2.3	49.4	37.6	16.0	32.1
4	4.7	13.3	6.6	8.2	1.6	14.4	9.3	4.1	10.8
6	1.7	4.2	4.8	2.5	0.8	4.5	3.1	1.7	2.8
2	355.2	155.0	363.2	256.7	259.5	267.2	444.2	621.0	335.8
56	0.43	4.54	1.68	1.27	0.09	4.00	1.35	0.28	1.63
06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
2	1.1	2.6	1.8	1.6	0.6	2.4	1.6	0.9	1.7

EK - MOUNTAIN

5	3365	10803	1979	5699	1061	6949	8059	5609	6422
.5	1864	10619	1567	4226	314	6650	6057	2712	5051
17	909	7918	1022	2626	85	4889	3814	1169	3278
9	443	5905	667	1632	23	3594	2398	504	2129
17	216	4406	434	1014	2	2644	1507	217	1381
8	105	3286	284	630		1943	948	94	897
51	51	2448	185	391		1428	594	22	581
27	16	1828	120	243		1051	374		377
6		1364	78	151		773	234		244
		1014	51	94		567	148		159
		756	33	58		417	93		103
		565	22	16		307	12		67
		420	10			225			26
		313				166			
		234				122			
		175				90			
		131				65			
		97				32			
		37							
25	6969	52319	6452	16780	1485	31912	24278	10327	20715

UNIT HYDR

AREAS BELOW 9,000 FEET, MSL,

SUBAREAS	502	505	510	515	520	522	524	526	528	530	54
D.A. (Sq. Mi.)	1.6	5.4	1.3	1.9	5.4	4.0	1.9	2.0	2.2	2.3	0.
L (Mi.)	1.9	5.2	1.4	3.0	5.5	4.2	2.4	3.6	4.2	2.7	3.
Lca (Mi.)	0.8	2.8	0.5	0.9	2.3	2.1	1.1	1.5	1.8	1.4	1.
SLOPE (Ft./Mi.)	849.5	564.6	735.3	280.5	448.7	731.4	310.6	191.0	179.9	579.9	394.
$LLca/S^{.5}$	0.05	0.61	0.03	0.17	0.61	0.34	0.16	0.40	0.56	0.16	0.
$\bar{n}$	0.075	0.075	0.075	0.06	0.06	0.075	0.06	0.04	0.04	0.06	0.
LAG (Hours)	0.6	1.5	0.5	0.8	1.2	1.2	0.7	0.7	0.8	0.7	0.
S-CURVE	1/	2/	2/	2/	2/	2/	1/	1/	1/	2/	1/
TIME PERIOD *(Hours)*											
1	741	1018	665	804	1390	1030	807	878	917	1022	269
2	175	1289	118	304	1280	950	251	251	328	358	12
3	59	604	37	69	446	331	85	85	110	76	41
4	23	270	6	21	189	140	40	39	54	25	21
5	3	136		14	70	52	16	12	25	16	12
6		61		2	38	28	1		5		6
7		33			30	22					1
8		27			23	17					
9		22			7	5					
10		18									
11		6									
12											
13											
14											
15											
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43											
44											
45											
46											
47											
TOTAL	1001	3484	826	1214	3459	2575	1200	1265	1439	1497	478

1/ Truckee Meadows average valley - GR/CB.

2/ Truckee Meadows average mountain - GR.

3/ Spanish Springs valley - GR/CB.

TABLE 9

UNIT HYDROGRAPH CHARACTERISTICS AND ORDINATES

9,000 FEET, MSL, FOR STANDARD PROJECT, DEC 1955 AND JAN-FEB 1963 FLOODS

	528	530	540	550	560	565	570	580	585	590	595	600	602	604	
	CHARACTERISTICS														
	2.2	2.3	0.7	2.1	1.2	2.1	0.3	4.0	2.0	2.4	1.4	0.4	2.5	1.8	
	4.2	2.7	3.2	3.0	2.1	3.2	1.0	4.0	2.2	2.9	2.6	1.7	3.8	2.4	
	1.8	1.4	1.7	2.1	1.0	1.5	0.5	2.0	1.2	1.5	1.3	0.6	2.3	1.5	
	179.9	579.9	394.4	323.4	488.2	161.9	111.1	212.1	107.2	229.6	87.1	40.9	187.9	25.3	6
0	0.56	0.16	0.28	0.35	0.10	0.38	0.06	0.55	0.26	0.29	0.38	0.17	0.63	0.70	
4	0.04	0.06	0.06	0.06	0.06	0.02	0.02	0.06	0.03	0.06	0.03	0.02	0.06	0.02	
	0.8	0.7	0.9	1.0	0.6	0.3	0.2	1.2	0.5	0.9	0.5	0.3	1.2	0.4	
	1/	2/	1/	2/	2/	1/	1/	2/	1/	1/	1/	1/	1/	1/	
	ONE HOUR UNIT HYDROGRAPH ORDINATES (End of period flow in c.f.s.)														
	917	1022	269	713	591	1194	192	1092	1097	839	726	269	534	958	2
	328	358	128	452	140	130	1	946	167	420	134	15	671	142	
	110	76	41	134	24	12		318	44	135	42		191	36	
	54	25	21	43	12			131	2	68	8		98	1	
	25	16	12	18	1			47		39			58		
	5		6	14				28		19			39		
			1	8				22		4			25		
								16					14		
								1					5		
	1439	1497	478	1382	768	1336	193	2601	1310	1524	910	284	1635	1137	2

S

JAN-FEB 1963 FLOODS

	590	595	600	602	604	606	610	620	625	630	640	650
	2.4	1.4	0.4	2.5	1.8	4.4	10.3	58.9	2.4	8.8	2.3	1.7
	2.9	2.6	1.7	3.8	2.4	4.7	7.0	13.5	2.7	5.7	2.6	5.1
	1.5	1.3	0.6	2.3	1.5	2.7	3.4	7.7	1.5	3.6	1.8	3.0
	229.6	87.1	40.9	187.9	25.3	68.1	189.4	135.5	175.8	128.3	11.6	11.7
5	0.29	0.38	0.17	0.63	0.70	1.55	1.75	8.93	0.31	1.83	1.35	4.47
3	0.06	0.03	0.02	0.06	0.02	0.02	0.06	0.17	0.04	0.06	0.04	0.06
	0.9	0.5	0.3	1.2	0.4	0.6	1.8	9.4	0.6	1.8	1.1	2.6
	1/	1/	1/	1/	1/	1/	2/	3/	1/	1/	1/	1/
	839	726	269	534	958	2165	1447	58	1118	665	618	58
	420	134	15	671	142	473	2288	154	279	2464	515	264
	135	42		191	36	158	1377	333	94	1075	151	336
	68	8		98	1	54	643	871	39	497	78	146
	39			58		2	363	2113		300	46	84
	19			39			200	3489		206	29	54
	4			25			103	4077		145	16	39
				14			56	3685		109	5	30
				5			46	3157		83		24
							39	2730		61		19
							34	2361		44		15
							28	2041		27		13
							12	1766		13		10
								1526		2		8
								1319				7
								1141				5
								987				3
								853				2
								737				1
								638				
								551				
								475				
								411				
								355				
								307				
								265				
								230				
								198				
								171				
								148				
								128				
								110				
								96				
								83				
								71				
								61				
								52				
								44				
								38				
								34				
								30				
								27				
								24				
								21				
								18				
								15				
								11				
	1524	910	284	1635	1137	2852	6636	38010	1536	5691	1458	1118

UNIT HYDROGR

DRAINAGE AREA BELOW 9,000 FEET, MSL, F(

SUBAREAS	15	20	25	30	35	40	42	44	46	48	50
D.A. (Sq. Mi.)	4.5	5.5	8.4	17.8	15.6	2.9	5.6	6.6	1.8	10.5	2.4
L (Mi.)	4.7	6.2	6.3	6.4	8.4	2.6	5.4	4.2	1.7	8.4	1.6
Lca (Mi.)	2.4	2.7	2.9	2.1	4.7	1.0	3.0	1.4	1.0	4.5	1.0
SLOPE (Ft./Mi.)	783.9	547.0	674.9	186.3	337.3	145.0	566.0	384.4	98.8	503.6	171.8
$LLca/S^{.5}$	0.4	0.72	0.71	0.99	2.13	0.23	0.69	0.29	0.18	1.67	0.12
$\bar{n}$	.075	.075	.075	.075	.075	.075	.075	.075	.07	.075	.07
LAG (Hours)	1.3	1.6	1.6	1.8	2.4	1.0	1.6	1.1	0.9	2.2	0.8
S-CURVE	1/	1/	1/	1/	1/	2/	1/	1/	2/	1/	2/

01

TIME PERIOD (Hours)	15	20	25	30	35	40	42	44	46	48	50
1	1049	943	1441	2478	1240	856	982	1843	670	998	988
2	1074	1291	1955	3943	2764	608	1318	1549	306	2031	345
3	405	668	1000	2386	2276	183	665	513	100	1520	116
4	178	300	449	1119	1440	94	299	207	50	878	56
5	73	162	240	631	801	56	158	73	28	472	26
6	33	79	116	350	502	33	76	46	12	305	5
7	25	37	55	181	339	16	36	36	2	189	
8	21	28	42	97	213	3	28	25		112	
9	14	24	35	80	131		24			63	
10		20	30	68	76		20			43	
11		15	23	58	58		15			38	
12		2	2	48	51					33	
13				22	45					29	
14					41					27	
15					37					21	
16					31					7	
17					21						
18											
19											
20											
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22											
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33											
34											
35											
36											
37											
38											
39											
40											
41											
42											
43											
44											
45											
TOTAL	2872	3569	5388	11461	10066	1849	3621	4292	1168	6766	1536

1/ Truckee Meadows average mountain - GR.

2/ Truckee Meadows average valley - GR/CB.

3/ Consists of subareas 621, 622, 623 and 624

TABLE 9

UNIT HYDROGRAPH CHARACTERISTICS AND ORDINATES

ƐEA BELOW 9,000 FEET, MSL, FOR THE STANDARD PROJECT GENERAL RAIN AND JAN-FEB 1963

CHARACTERISTICS

42	44	46	48	50	60	62 3/	64	66	68	70	72	74	76	:
5.6	6.6	1.8	10.5	2.4	22.4	10.2	4.6	8.4	2.9	3.5	1.9	4.7	2.7	2
5.4	4.2	1.7	8.4	1.6	7.7	4.7	2.5	6.8	3.0	3.7	2.5	4.3	2.8	4
3.0	1.4	1.0	4.5	1.0	2.7	1.5	1.2	3.9	1.4	1.9	1.2	1.7	1.6	2
56.0	384.4	98.8	503.6	171.8	246.4	590.1	129.9	557.5	215.7	29.9	80.0	327.1	14.1	25
0.69	0.29	0.18	1.67	0.12	1.32	0.29	0.27	1.14	0.28	1.28	0.34	0.41	1.18	2
.075	.075	.07	.075	.07	.07	.075	.07	.075	.075	.07	.04	.04	.04	
1.6	1.1	0.9	2.2	0.8	1.9	1.1	1.0	1.9	1.1	1.8	0.6	0.7	1.0	1
1/	1/	2/	1/	2/	2/	1/	2/	1/	2/	2/	2/	2/	2/	:

ONE HOUR UNIT HYDROGRAPH ORDINATES

(End of period flow in c.f.s.)

42	44	46	48	50	60	62 3/	64	66	68	70	72	74	76
982	1843	670	998	988	1554	2827	1361	1065	752	249	868	2081	809
1318	1549	306	2031	345	6105	2376	976	1816	697	955	228	607	567
665	513	100	1520	116	2849	787	294	1164	203	435	77	205	171
299	207	50	878	56	1311	318	151	577	104	200	33	95	88
158	73	28	472	26	784	112	89	319	62	120	7	32	52
76	46	12	305	5	534	70	54	189	40	82		1	31
36	36	2	189		383	55	26	103	23	59			15
28	25		112		283	38	5	53	9	43			3
24			63		219			38	1	33			
20			43		166			33		25			
15			38		121			28		18			
			33		82			25		12			
			29		44			19		6			
			27		15			5		2			
			21										
			7										
3621	4292	1168	6766	1536	14450	6583	2956	5434	1891	2239	1213	3021	1736

N AND JAN-FEB 1963 FLOODS

72	74	76	78	80	82	84	700	720	730	740	760
1.9	4.7	2.7	2.1	2.8	2.5	5.6	1.5	241.0	49.0	96.0	93.4
2.5	4.3	2.8	4.4	3.4	4.2	4.8	1.9	32.5	13.5	18.3	18.8
1.2	1.7	1.6	2.5	1.7	1.2	3.1	0.5	9.1	6.7	6.9	6.1
80.0	327.1	14.1	25.0	123.9	4.8	88.7	393.0	92.3	293.6	200.0	151.1
0.34	0.41	1.18	2.17	0.54	2.21	1.61	0.05	30.77	5.28	8.93	9.33
.04	.04	.04	.04	.07	.07	.07	.07	.07	.07	.07	.07
0.6	0.7	1.0	1.3	1.3	2.3	2.0	0.6	6.2	3.2	3.9	3.9
2/	2/	2/	2/	2/	2/	2/	1/	2/	1/	1/	1/
868	2081	809	380	463	110	319	753	2933	2271	2988	2812
228	607	567	602	820	508	1426	155	8801	6180	8712	8218
77	205	171	172	237	425	791	51	14248	6401	10658	10216
33	95	88	87	118	184	357	15	17184	5071	9804	9487
7	32	52	53	73	105	209		16298	3576	7680	7484
	1	31	35	48	71	143		15731	2295	5716	5638
		15	23	33	51	104		13380	1523	4012	4007
		3	15	21	39	77		11488	1114	2765	2740
			7	12	30	60		9535	826	2068	2056
			1	4	24	47		7701	585	1653	1644
					19	36		6146	404	1282	1285
					15	27		4688	276	966	977
					12	18		4006	183	709	719
					9	10		3263	140	527	543
					6	4		2877	131	374	392
					3			2462	118	274	281
					1			2117	108	223	218
								1768	100	215	210
								1490	90	195	192
								1207	87	181	177
								1021	72	169	165
								839	62	159	156
								691	10	144	142
								539		142	136
								454		126	130
								375		106	109
								349		98	95
								345		5	47
								327			
								308			
								293			
								280			
								268			
								260			
								248			
								231			
								224			
								222			
								215			
								190			
								172			
								156			
								154			
								40			
1213	3021	1736	1375	1829	1612	3628	974	155524	31623	61951	60276

TABLE 10

UNIT HYDROGRAPH CHARACTERISTICS AND ORDINATES
DRAINAGE AREA BELOW 9,000 FEET, MSL, FOR THE PROBABLE MAXIMUM GENERAL RAIN FLOODS

SUBAREAS	15	20	25	30	35	40	42	44	46	48	50	60
CHARACTERISTICS												
D.A. (Sq. Mi.)	4.5	5.5	8.4	17.8	15.6	2.9	5.6	6.6	1.8	10.5	2.4	22.4
L (Mi.)	4.7	6.2	6.3	6.4	8.4	2.6	5.4	4.2	1.7	8.4	1.6	7.7
Lca (Mi.)	2.4	2.7	2.9	2.1	4.7	1.0	3.0	1.4	1.0	4.5	1.0	2.7
SLOPE (Ft./Mi.)	783.9	547.0	674.9	186.3	337.3	145.0	566.0	384.4	98.8	503.6	171.8	246.5
$LLca/S^{.5}$	0.40	0.72	0.71	0.99	2.13	0.23	0.69	0.29	0.18	1.67	0.12	1.32
$\bar{n}$	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.056	0.06	0.056	0.056
LAG (Hours)	1.0	1.3	1.3	1.4	1.9	0.8	1.3	0.9	0.7	1.8	0.6	1.5
S-CURVE	1/	1/	1/	1/	1/	2/	1/	1/	2/	1/	2/	2/
ONE HOUR UNIT HYDROGRAPH ORDINATES *(End of period flow in c.f.s.)*												
TIME PERIOD *(Hours)*												
1	1400	1304	1990	3536	1919	1120	1354	2377	797	1520	1129	2745
2	973	1335	2013	4278	3335	455	1351	1326	239	2352	273	6675
3	302	504	752	1897	2172	150	499	374	81	1387	92	2141
4	105	221	329	845	1093	74	217	108	38	639	37	1040
5	40	90	133	409	601	39	87	56	14	362	5	642
6	29	41	61	176	361	13	40	41	1	196		426
7	22	31	47	105	198		32	10		98		303
8	3	26	38	86	103		26			56		215
9		18	25	72	71		15			46		145
10				54	61					40		84
11					53					34		32
12					47					27		1
13					37					7		
14					15							
TOTAL	2874	3570	5388	11458	10066	1851	3621	4292	1170	6764	1536	14449

1/ Truckee Meadows average mountain - GR.
2/ Truckee Meadows average valley - GR/CB.

UNIT HYDROG
DRAINAGE AREAS

SUBAREAS	15	20	201	25	30	35	40	42	44	46	4
D.A. (Sq. Mi.)	4.6	1.0	7.5	8.4	17.8	15.6	2.9	8.0	6.6	1.8	11
L (Mi.)	4.8	2.7	5.5	6.3	6.4	8.4	2.6	5.8	4.2	1.7	8
Lca (Mi.)	2.6	1.7	3.3	2.9	2.1	4.7	1.0	3.9	1.4	1.0	5
Slope (Ft./Mi.)	854.7	688.7	694.1	674.9	186.3	337.3	145.0	697.4	384.4	98.8	571
$LLca/S^{.5}$	0.43	0.18	0.68	0.71	0.99	2.13	0.23	0.85	0.29	0.18	1
$\bar{n}$	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.07	0
Lag (Hours)	1.3	1.0	1.6	1.6	1.8	2.4	1.0	1.7	1.1	0.9	2
S-Curve	1/	1/	1/	1/	1/	1/	2/	1/	1/	2/	:
TIME PERIOD *(1/4 Hours)*											
1	348	137	393	425	652	424	147	340	657	131	
2	885	370	1060	1154	1901	969	479	963	1676	472	
3	1345	471	1635	1785	3024	1488	1134	1510	2449	1089	1
4	1519	420	2007	2203	3934	1988	1673	1918	2460	990	1
5	1409	341	2056	2272	4336	2572	1053	2052	2151	508	1
6	1219	264	1896	2106	4201	2761	629	1949	1768	323	2
7	1035	194	1678	1884	3845	2822	431	1766	1446	226	2
8	870	141	1459	1638	3466	2760	319	1576	1106	168	2
9	683	105	1255	1409	3087	2533	241	1385	850	130	1
10	549	79	1060	1196	2706	2364	196	1201	654	106	1
11	437	60	878	994	2349	2199	161	1022	511	89	1
12	346	43	723	821	1992	2033	136	856	412	74	1
13	286	30	594	678	1682	1784	117	715	322	62	1
14	235	19	487	564	1415	1629	100	597	246	52	1
15	191	10	413	476	1195	1473	86	503	191	46	1
16	151	1	349	395	1018	1313	75	432	130	40	
17	121		300	342	884	1115	66	365	89	35	
18	90		259	289	753	996	59	316	43	30	
19	66		202	236	663	888	52	271	6	25	
20	42		171	198	574	788	46	227		21	
21	22		133	162	484	675	41	186		18	
22	1		100	122	398	615	35	161		14	
23			76	92	352	556	31	128		10	
24			52	65	285	497	26	98		7	
25			27	38	220	439	22	76		5	
26			2	11	175	400	18	53		2	
27					130	361	14	31			
28					86	321	10	7			
29					39	265	7				
30						244	4				
31						220	1				
32						190					
33						147					
34						127					
35						107					
36						88					
37						59					
38						40					
39						18					
40											
41											
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59											
60											
61											
62											
63											
64											
65											
66											
67											
TOTAL	11850	2685	19257	21555	45646	40268	7409	20704	17167	4673	2[illegible]

1/ Truckee Meadows average mountain – CB.

2/ Truckee Meadows average valley – GR/CB.

TABLE II

UNIT HYDROGRAPH CHARACTERISTICS AND ORDINATES
DRAINAGE AREAS FOR STANDARD PROJECT CLOUDBURST FLOODS

CHARACTERISTICS

5	30	35	40	42	44	46	48	50	60	621	622	623	624	64	66	
	17.8	15.6	2.9	8.0	6.6	1.8	11.4	2.4	22.4	1.4	3.6	3.0	2.2	4.6	8.4	
	6.4	8.4	2.6	5.8	4.2	1.7	8.8	1.6	7.7	2.4	4.7	3.4	3.0	2.5	6.8	
	2.1	4.7	1.0	3.9	1.4	1.0	5.1	1.0	2.7	1.1	2.4	1.7	1.3	1.2	3.9	
	186.3	337.3	145.0	697.4	384.4	98.8	571.1	171.8	246.4	397.9	582.6	774.2	550.7	129.9	557.5	21
1	0.99	2.13	0.23	0.85	0.29	0.18	1.87	0.12	1.32	0.14	0.48	0.22	0.17	0.27	1.14	
75	0.075	0.075	0.075	0.075	0.075	0.07	0.075	0.07	0.07	0.075	0.075	0.075	0.075	0.07	0.075	
	1.8	2.4	1.0	1.7	1.1	0.9	2.3	0.8	1.9	0.85	1.37	1.01	0.92	1.0	1.9	
	1/	1/	2/	1/	1/	2/	1/	2/	2/	1/	1/	1/	1/	2/	1/	

1/4-HOUR UNIT HYDROGRAPH ORDINATES

(End of period flow in c.f.s.)

5	30	35	40	42	44	46	48	50	60	621	622	623	624	64	66
25	652	424	147	340	657	131	325	225	404	233	240	355	312	233	290
54	1901	969	479	963	1676	472	782	887	983	592	675	926	804	758	821
35	3024	1488	1134	1510	2449	1089	1210	1794	1780	698	979	1248	1016	1794	1303
03	3934	1988	1673	1918	2460	990	1602	1049	3053	584	1152	1174	898	2659	1702
72	4336	2572	1053	2052	2151	508	1977	567	4786	452	1094	970	717	1693	1913
36	4201	2761	629	1949	1768	323	2167	363	6574	329	959	780	550	1009	1907
84	3845	2822	431	1766	1446	226	2141	257	7359	227	826	596	394	691	1781
38	3466	2760	319	1576	1106	168	2050	193	5707	164	698	434	285	511	1623
09	3087	2533	241	1385	850	130	1919	153	4015	119	574	327	212	385	1462
96	2706	2364	196	1201	654	106	1747	125	3041	87	454	251	159	315	1300
94	2349	2199	161	1022	511	89	1589	100	2386	61	363	193	118	258	1144
21	1992	2033	136	856	412	74	1451	84	1950	40	295	147	86	217	992
78	1682	1784	117	715	322	62	1315	71	1650	23	242	110	57	187	848
64	1415	1629	100	597	246	52	1184	61	1404	5	198	78	34	160	722
76	1195	1473	86	503	191	46	1008	51	1166		165	49	1	138	613
95	1018	1313	75	432	130	40	891	43	1021		134	24		120	523
42	884	1115	66	365	89	35	788	35	935		107	5		105	450
89	753	996	59	316	43	30	695	29	808		87			94	393
36	663	888	52	271	6	25	605	23	719		64			84	338
98	574	788	46	227		21	521	16	672		46			74	300
62	484	675	41	186		18	471	11	595		29			65	260
22	398	615	35	161		14	422	6	559		15			57	222
92	352	556	31	128		10	376	2	511					49	184
65	285	497	26	98		7	336		470					43	163
38	220	439	22	76		5	298		431					36	136
11	175	400	18	53		2	266		391					30	108
	130	361	14	31			233		368					22	86
	86	321	10	7			201		343					17	67
	39	265	7				179		310					12	48
		244	4				154		291					7	29
		220	1				130		274					2	9
		190					107		258						
		147					90		243						
		127					68		226						
		107					52		210						
		88					36		197						
		59					18		185						
		40							172						
		18							159						
									146						
									135						
									125						
									116						
									106						
									97						
									87						
									78						
									65						
									56						
									49						
									39						
									32						
									27						
									19						
									11						
									4						
555	45646	40268	7409	20704	17167	4673	29404	6145	57798	3614	9396	7667	5643	11825	21737

S AND ORDINATES
T CLOUDBURST FLOODS

	622	623	624	64	66	68	70	72	74	76	78	80	82	84
	3.6	3.0	2.2	4.6	8.4	2.9	3.5	1.9	4.7	2.7	2.1	2.8	2.5	5.6
	4.7	3.4	3.0	2.5	6.8	3.0	3.7	2.5	4.3	2.8	4.4	3.4	4.2	4.8
	2.4	1.7	1.3	1.2	3.9	1.4	1.9	1.2	1.7	1.6	2.5	1.7	1.2	3.1
	582.6	774.2	550.7	129.9	557.5	215.7	29.9	80.0	327.1	14.1	25.0	123.9	4.8	88.7
ı	0.48	0.22	0.17	0.27	1.14	0.28	1.28	0.34	0.41	1.18	2.17	0.54	2.21	1.61
'5	0.075	0.075	0.075	0.07	0.075	0.075	0.07	0.04	0.04	0.04	0.04	0.07	0.07	0.07
i	1.37	1.01	0.92	1.0	1.9	1.0	1.9	0.3	0.4	0.5	0.6	0.4	2.0	1.7
	1/	1/	1/	2/	1/	2/	2/	2/	2/	2/	2/	2/	2/	2/
INATES														
.s.)														
	240	355	312	233	290	133	64	245	530	138	77	97	35	35
	675	926	804	758	821	405	157	1109	2316	452	198	241	76	76
	979	1248	1016	1794	1303	925	285	1475	3712	1072	460	563	128	128
	1152	1174	898	2659	1702	1546	490	643	1766	1575	786	950	203	203
	1094	970	717	1693	1913	1231	765	368	988	981	1007	1315	310	310
	959	780	550	1009	1907	715	1051	239	634	587	669	951	438	438
	826	596	394	691	1781	483	1139	172	457	403	427	588	567	567
	698	434	285	511	1623	359	866	133	350	297	304	428	720	720
	574	327	212	385	1462	270	612	103	277	225	235	319	612	612
	454	251	159	315	1300	215	464	82	219	183	183	257	453	453
	363	193	118	258	1144	176	364	67	177	151	146	199	351	351
	295	147	86	217	992	149	299	56	149	127	125	171	281	281
	242	110	57	187	848	128	253	46	124	109	104	143	230	230
	198	78	34	160	722	111	214	37	103	93	91	125	193	193
	165	49	1	138	613	96	176	29	84	81	80	103	167	167
	134	24		120	523	83	157	22	68	70	70	97	146	146
	107	5		105	450	74	143	15	53	61	63	86	126	126
	87			94	393	64	124	9	37	55	54	76	108	108
	64			84	338	58	111	4	24	49	50	67	97	97
	46			74	300	52	102		13	43	44	62	89	89
	29			65	260	47	92		2	38	40	54	82	82
	15			57	222	42	86			33	36	50	73	73
				49	184	37	78			28	33	46	66	66
				43	163	32	72			25	30	42	63	63
				36	136	28	66			21	27	38	56	56
				30	108	25	60			17	25	34	53	53
				22	86	21	57			13	22	31	50	50
				17	67	18	52			9	20	28	46	46
				12	48	14	47			7	18	25	43	43
				7	29	11	45			4	16	22	41	41
				2	9	8	42			1	14	20	37	37
						5	39				12	18	35	35
						2	37				10	15	33	33
							34				8	13	31	31
							32				6	10	29	29
							30				5	8	27	27
							28				3	6	26	26
							26				2	4	25	25
							24					3	24	24
							22					1	22	22
							21						21	21
							19						20	20
							17						19	19
							16						18	18
							14						17	17
							13						16	16
							11						15	15
							9						14	14
							8						13	13
							7						12	12
							6						12	12
							5						11	11
							4						10	10
							2						9	9
													9	9
													8	8
													7	7
													6	6
													5	5
													5	5
													4	4
													4	4
													3	3
													3	3
													2	2
													1	1
													1	1
	9396	7667	5643	11825	21737	7563	8957	4853	12081	6947	5500	7306	6454	14513

TABLE 11

TA

UNIT HYDROGRAPH CHARA

DRAINAGE AREAS FOR PROBAB

SUBAREAS	15	20	201	25	30	3
						CHARA
D.A. (Sq. Mi.)	4.6	1.0	7.5	8.4	17.8	15
L (Mi.)	4.8	2.7	5.5	6.3	6.4	8
Lea (Mi.)	2.6	1.7	3.3	2.9	2.1	4
SLOPE (Ft./Mi.)	854.7	688.7	694.1	674.9	186.3	337
$LLca/S^{.5}$	0.43	0.18	0.68	0.71	0.99	2
$\bar{n}$	0.06	0.06	0.06	0.06	0.06	0
Lag (Hours)	1.1	0.8	1.3	1.3	1.4	1
S-CURVE	1/	1/	1/	1/	1/	1

1/4 HOUR UNIT HY

(End of perioa

TIME PERIOD *(1/4 Hours)*						
1	515	213	620	676	1121	
2	1350	527	1558	1703	2929	1
3	1852	559	2384	2601	4459	2
4	1780	437	2579	2849	5322	3
5	1493	320	2328	2600	5164	3
6	1216	215	1994	2220	4616	3
7	950	145	1682	1893	4049	3
8	700	103	1346	1520	3474	2
9	528	72	1082	1220	2849	2
10	408	48	825	954	2339	2
11	315	29	662	748	1906	2
12	246	14	529	613	1545	1
13	184	1	430	485	1242	1
14	140		352	408	1041	1
15	91		273	318	876	1
16	58		221	252	738	
17	24		161	196	585	
18			117	136	476	
19			74	98	392	
20			38	51	289	
21			2	11	209	
22					142	
23					75	
24					6	
25						
26						
27						
28						
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						
41						
42						
43						
44						
45						
TOTAL	11850	2683	19257	21552	45844	4

1/ Truckee Meadows average mountain - CB.

2/ Truckee Meadows average valley - GR/CB.

TABLE 12

UNIT HYDROGRAPH CHARACTERISTICS AND ORDINATES
DRAINAGE AREAS FOR PROBABLE MAXIMUM CLOUDBURST FLOODS

201	25	30	35	40	42	44	46	48
			CHARACTERISTICS					
7.5	8.4	17.8	15.6	2.9	8.0	6.6	1.8	11.4
5.5	6.3	6.4	8.4	2.6	5.8	4.2	1.7	8.8
3.3	2.9	2.1	4.7	1.0	3.9	1.4	1.0	5.1
94.1	674.9	186.3	337.3	145.0	697.4	384.4	98.8	571.1
0.68	0.71	0.99	2.13	0.23	0.85	0.29	0.18	1.87
0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.056	0.06
1.3	1.3	1.4	1.9	0.8	1.4	0.9	0.7	1.8
1/	1/	1/	1/	2/	1/	1/	2/	1/
			1/4 HOUR UNIT HYDROGRAPH ORDINATES *(End of period flow in c.f.s.)*					
620	676	1121	530	234	565	937	199	406
1558	1703	2929	1483	866	1452	2554	858	1176
2384	2601	4459	2348	1940	2195	3162	1429	1867
2579	2849	5322	3072	1442	2561	2726	701	2439
2328	2600	5164	3470	756	2407	2172	389	2710
1994	2220	4616	3489	478	2134	1639	249	2651
1682	1893	4049	3278	332	1810	1177	179	2444
1346	1520	3474	2996	252	1524	843	137	2212
1082	1220	2849	2707	197	1261	624	109	1978
825	954	2339	2417	162	995	472	86	1745
662	748	1906	2134	132	794	341	70	1523
529	613	1545	1862	110	646	247	58	1303
430	485	1242	1596	92	527	157	49	1105
352	408	1041	1362	79	430	90	41	934
273	318	876	1160	69	364	24	34	790
221	252	738	986	58	292		27	673
161	196	585	843	50	229		22	584
117	136	476	740	42	188		16	501
74	98	392	638	35	136		10	438
38	51	289	564	29	97		6	383
2	11	209	496	22	64		2	328
		142	428	16	28			273
		75	359	10				235
		6	310	6				199
			268	1				158
			217					124
			172					97
			137					69
			103					42
			70					13
			33					
9257	21552	45844	40268	7410	20699	17165	4671	29400

CB.
'/CB.

ORDINATES
JDBURST FLOODS

42	44	46	48	50	60
8.0	6.6	1.8	11.4	2.4	22.4
5.8	4.2	1.7	8.8	1.6	7.7
3.9	1.4	1.0	5.1	1.0	2.7
697.4	384.4	98.8	571.1	171.8	246.4
0.85	0.29	0.18	1.87	0.12	1.32
0.06	0.06	0.056	0.06	0.056	0.056
1.4	0.9	0.7	1.8	0.6	1.5
1/	1/	2/	1/	2/	2/

S

565	937	199	406	354	631
1452	2554	858	1176	1617	1552
2195	3162	1429	1867	1781	2987
2561	2726	701	2439	764	5814
2407	2172	389	2710	435	8518
2134	1639	249	2651	288	8713
1810	1177	179	2444	209	5557
1524	843	137	2212	161	3910
1261	624	109	1978	124	2933
995	472	86	1745	98	2268
794	341	70	1523	81	1856
646	247	58	1303	66	1506
527	157	49	1105	53	1260
430	90	41	934	41	1106
364	24	34	790	32	944
292		27	673	22	849
229		22	584	13	738
188		16	501	6	680
136		10	438		605
97		6	383		544
64		2	328		486
28			273		451
			235		401
			199		366
			158		340
			124		314
			97		291
			69		267
			42		244
			13		225
					206
					185
					167
					153
					137
					123
					108
					91
					74
					63
					48
					38
					29
					15
					4
20699	17165	4671	29400	6145	57797

3

TABLE 12

TABLE 15

UNREGULATED CONDITION FLOWS - TRUCKEE RIVER
(OCTOBER - MARCH)

(Flows in c.f.s.)

WATER YEAR	TRUCKEE R!VER AT FARAD						TRUCKEE RIVER AT RENO					
	PEAK	1 DAY	3 DAY	7 DAY	15 DAY	30 DAY	PEAK	1 DAY	3 DAY	7 DAY	15 DAY	30 DAY
1900												
1901												
1902		1194	874	733	626	515						
1903		3211	2565	1315	827	610						
1904		6730	5050	3512	2613	2591						
1905		1821	1496	1393	1357	1091						
1906		1280										
1907		15300	9260	6420	3897	2236		14600	11493	7062	4416	2726
1908		1393	1329	1295	1284	1130						
1909		8810	7010	4952	3280	2207		8540	7303	5118	3423	2313
1910		3890	3106	2421	2114	1700		3360	3053	2504	2246	1891
1911		2230	2100	1852	1502	1207						
1912		910	894	848	819	616						
1913		810	650	540	490	469		1100	700	536	474	437
1914		2700	2426	2277	1970	1422	7520	3540	3210	2350	2030	1510
1915		927	862	821	702	604		940	887	860	720	560
1916		3540	3123	2667	2328	1966		3870	3420	2850	2450	2040
1917		965	812	743	637	578		1060	899	724	594	536
1918		1620	860	719	629	580		920	853	804	712	622
1919		1040	927	765	641	570		1170	910	746	589	502
1920		595	545	521	514	494						
1921		1930	1640	1377	1184	1017						
1922		542	534	522	515	500						
1923		1200	1116	955	768	636						
1924		767	639	530	493	454						
1925		3430	2116	1352	856	611						
1926		756	720	677	651	529						
1927		2160	1890	1422	1188	992						
1928		12000	9866	5585	2995	1723						
1929		756	551	450	409	340						
1930		1360	1283	1197	867	581						
1931		888	694	579	420	307		759	621	564	412	291
1932		1340	1190	1016	776	506		1240	1200	1040	847	564
1933		226	205	179	162	142		211	199	167	151	128

1917		965	812	743	637	578		1060	899	724	594	536
1918		1620	860	719	629	580		920	853	804	712	622
1919		1040	927	765	641	570		1170	910	746	589	502
1920		595	545	521	514	494						
1921		1930	1640	1377	1184	1017						
1922		542	534	522	515	500						
1923		1200	1116	955	768	636						
1924		767	639	530	493	454						
1925		3430	2116	1352	856	611						
1926		756	720	677	651	529						
1927		2160	1890	1422	1188	992						
1928		12000	9866	5585	2995	1723						
1929		756	551	450	409	340						
1930		1360	1283	1197	867	581						
1931		888	694	579	420	307		759	621	564	412	291
1932		1340	1190	1016	776	506		1240	1200	1040	847	564
1933		226	205	179	162	142		211	199	167	151	128
1934		2500	1839	1301	989	710		1790	1500	1020	790	569
1935		421	320	239	201	177						
1936		1549	1459	1281	1073	823						
1937		792	668	609	563	524						
1938	15500	12300	7833	4642	2562	1408						
1939		1174	1148	1004	816	639						
1940		5440	4660	3747	2195	1426						
1941		1130	937	749	580	529						
1942		1579	1537	1491	1469	1182						
1943		4984	3049	2899	2509	2474		6462	4062	2950	2720	2434
1944		529	489	428	381	359						
1945		1976	1388	957	767	593						
1946		1575	1347	1043	775	551		1110	1028	918	838	793
1947		1388	1236	824	722	679		1239	1205	883	613	483
1948		1179	842	662	478	333		1016	838	664	484	343
1949		453	451	441	418	366		322	313	307	285	238
1950		1104	1042	918	745	627		1349	1072	958	779	663
1951	18000	11000	9412	6662	3894	3450	20500	15662	10555	6491	3883	3581
1952		1825	1821	1805	1748	1693		2734	2632	2170	2052	1923
1953		1358	1351	1341	1324	1244		1726	1424	1421	1402	1315
1954		2548	2084	1372	946	694		2801	2311	1536	1036	750
1955		662	572	518	458	420		630	596	519	461	420
1956	24600	21668	12646	6900	3772	3422	27800	25666	14611	7902	4370	2780
1957		1801	1757	1638	1524	1276		1973	1829	1700	1568	1329
1958		1590	1381	1098	814	640		2501	1935	1426	1012	765
1959		1046	946	775	609	595		742	632	605	592	538

1941		1130	937	749	580	529						
1942		1579	1537	1491	1469	1182						
1943		4984	3049	2899	2509	2474		6462	4062	2950	2720	2434
1944		529	489	428	381	359						
1945		1976	1388	957	767	593						
1946		1575	1347	1043	775	551		1110	1028	918	838	793
1947		1388	1236	824	722	679		1239	1205	883	613	483
1948		1179	842	662	478	333		1016	838	664	484	343
1949		453	451	441	418	366		322	313	307	285	238
1950		1104	1042	918	745	627		1349	1072	958	779	663
1951	18000	11000	9412	6662	3894	3450	20500	15662	10555	6491	3883	3581
1952		1825	1821	1805	1748	1693		2734	2632	2170	2052	1923
1953		1358	1351	1341	1324	1244		1726	1424	1421	1402	1315
1954		2548	2084	1372	946	694		2801	2311	1536	1036	750
1955		662	572	518	458	420		630	596	519	461	420
1956	24600	21668	12646	6900	3772	3422	27800	25666	14611	7902	4370	2780
1957		1801	1757	1638	1524	1276		1973	1829	1700	1568	1329
1958		1590	1381	1098	814	640		2501	1935	1426	1012	765
1959		1046	946	775	609	595		742	632	605	592	538
1960		1499	1334	1196	985	843		1825	1311	1167	943	824
1961		589	532	511	481	398		380	354	345	297	269
1962		715	635	492	354	269		789	672	510	355	274
1963	30500	20119	11441	6674	3825	2283	33400	24485	13343	7894	4398	2634
1964		1788	1255	829	674	539		1482	1242	838	680	554
1965	24000	17237	14120	8533	4767	2819	24300	14556	12938	8714	4731	7802
1966		2095	2085	2065	1827	1271		1931	1928	1917	1730	1201
1967		3534	2952	2312	1769	1190		3886	3563	2841	2140	1391
1968		2173	1875	1684	1364	1071		2336	2174	1871	1489	1132
1969		3857	3346	2732	2321	2100		4307	3653	2957	2505	2222
1970		10221	7850	5918	4523	3393		9255	8314	6881	5075	3816
1971		1330	1256	1125	1040	991		1436	1375	1276	1128	1062
1972		1576	1505	1454	1380	1250		1430	1411	1319	1259	1100
1973		1408	1208	990	713	562		1286	1243	1067	780	583
1974		3679	2771	2317	1921	1626		4220	4000	3095	1964	1701
1975		855	768	662	590	540		1475	1008	797	671	620
1976		979	733	585	479	463		904	664	521	415	361
1977		562	551	543	509	408		557	536	452	394	383

COMPUTED STATISTICS

Years Record	76	75	75	75	75		47	47	47	47	47
Log Mean	3.259	3.183	3.095	3.001	2.907		3.304	3.231	3.137	3.035	2.950
Log Std. Dev.	.424	.397	.361	.322	.299		.477	.450	.411	.376	.375
Skew	.810	.680	.479	.236	.158		.589	.461	.305	.093	.223

EXTENDED STATISTICS BASED ON MULTIPLE CORRELATION

1963	30500	20119	11441	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1964		1788	1255	829	674	539		1482	1242	838	680	554
1965	24000	17237	14120	8533	4767	2819	24300	14556	12938	8714	4731	7802
1966		2095	2085	2065	1827	1271		1931	1928	1917	1730	1201
1967		3534	2952	2312	1769	1190		3886	3563	2841	2140	1391
1968		2173	1875	1684	1364	1071		2336	2174	1871	1489	1132
1969		3857	3346	2732	2321	2100		4307	3653	2957	2505	2222
1970		10221	7850	5918	4523	3393		9255	8314	6881	5075	3816
1971		1330	1256	1125	1040	991		1436	1375	1276	1128	1062
1972		1576	1505	1454	1380	1250		1430	1411	1319	1259	1100
1973		1408	1208	990	713	562		1286	1243	1067	780	583
1974		3679	2771	2317	1921	1626		4220	4000	3095	1964	1701
1975		855	768	662	590	540		1475	1008	797	671	620
1976		979	733	585	479	463		904	664	521	415	361
1977		562	551	543	509	408		557	536	452	394	383
COMPUTED STATISTICS												
Years Record		76	75	75	75	75		47	47	47	47	47
Log Mean		3.259	3.183	3.095	3.001	2.907		3.304	3.231	3.137	3.035	2.950
Log Std. Dev.		.424	.397	.361	.322	.299		.477	.450	.411	.376	.375
Skew		.810	.680	.479	.236	.158		.589	.461	.305	.093	.223
EXTENDED STATISTICS BASED ON MULTIPLE CORRELATION												
Equiv. Years Record		76.9	77	77	76.9	76.9		76.5	76.8	76.8	76.8	76.5
Log Mean		3.266	3.189	3.100	3.004	2.91		3.276	3.203	3.109	3.008	2.919
Log Std. Dev.		.425	.397	.359	.319	.296		.439	.416	.381	.347	.345
Skew		.767	.651	.448	.213	.133		.595	.485	.399	.178	.313
ADOPTED STATISTICS												
Equiv. Years Record		77	77	77	77	77		77	77	77	77	77
Log Mean		3.266	3.189	3.100	3.004	2.910		3.276	3.203	3.109	3.008	2.919
Log Std. Dev.		.38	.36	.34	.32	.29		.40	.38	.35	.33	.30
Skew		.6	.5	.4	.2	.1		.6	.5	.4	.2	.1

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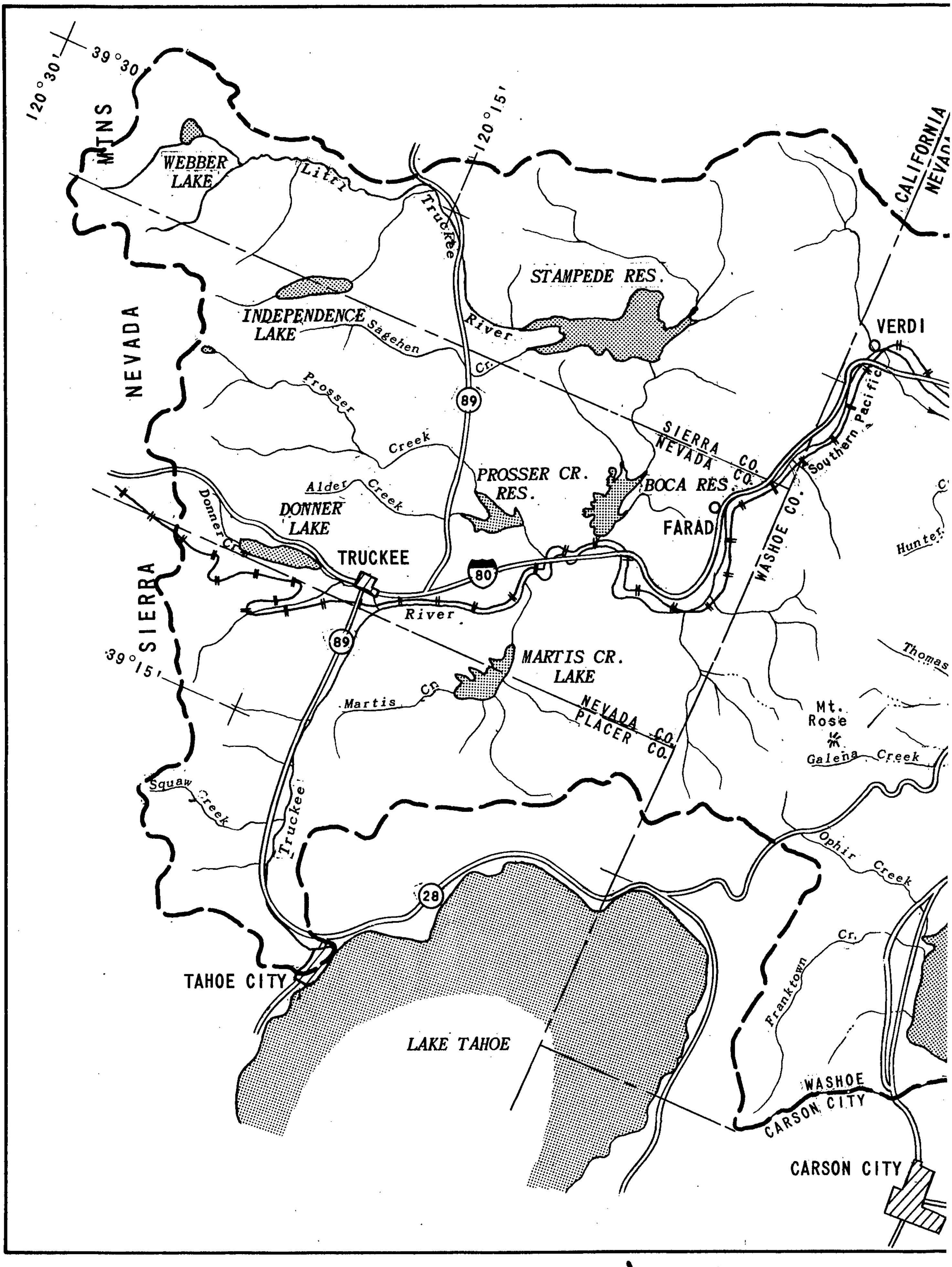
TABLE 15

UNREGULATED CONDITION FLOWS - TRUCKEE RIVER
(OCTOBER - MARCH)
(Flows in c.f.s.)

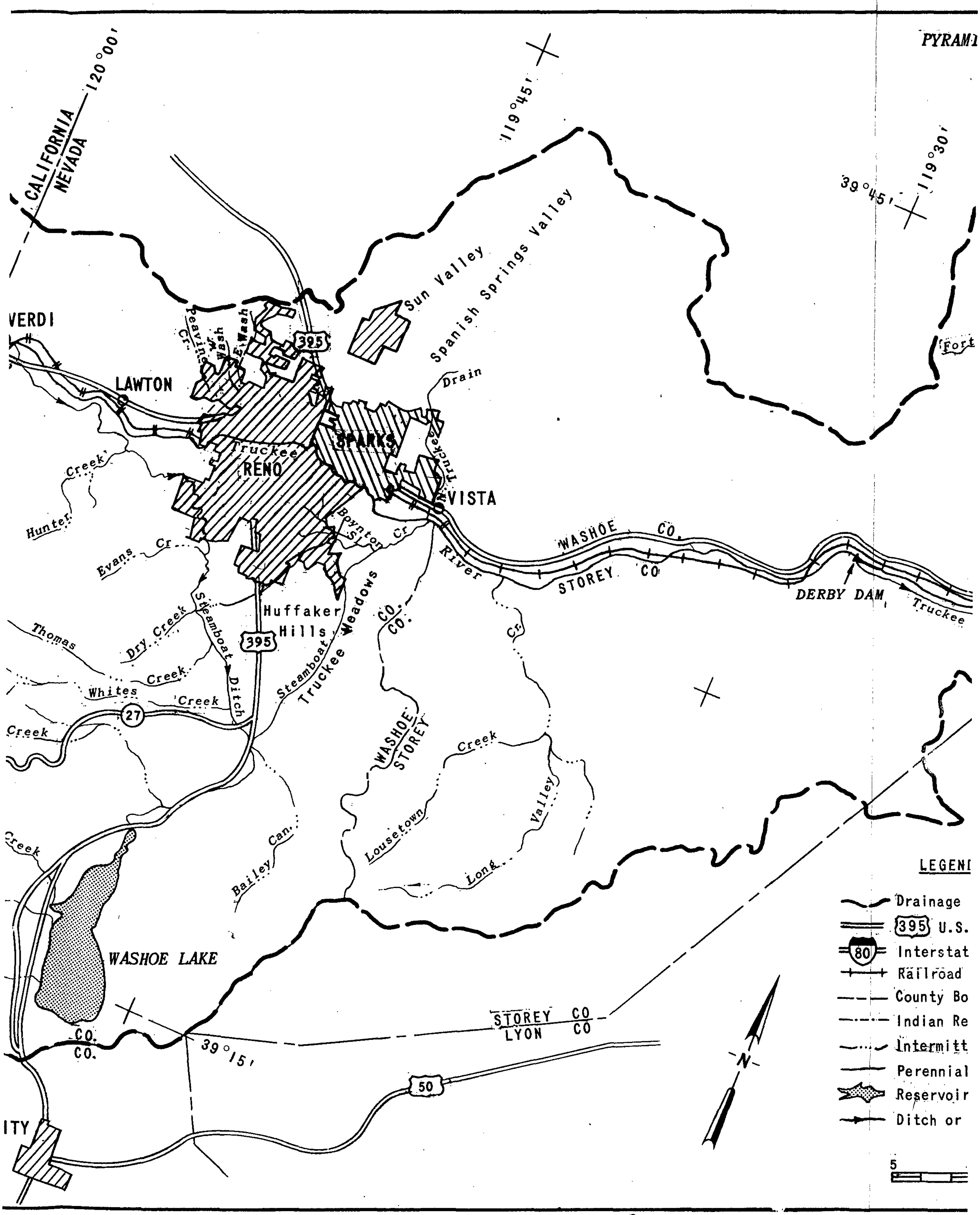
WATER YEAR	TRUCKEE RIVER NR VISTA						TRUCKEE RIVER BELOW DERBY DAM NEAR WADSWORTH						TRUCKEE RIVER NEAR NIXON					
	PEAK	1 DAY	3 DAY	7 DAY	15 DAY	30 DAY	PEAK	1 DAY	3 DAY	7 DAY	15 DAY	30 DAY	PEAK	1 DAY	3 DAY	7 DAY	15 DAY	30 DAY
1900																		
1901		4210	3580	3170	2640	2030												
1902		1290	1030	855	794	709												
1903		5650	4110	2390	1480	1090												
1904		8280	6610	5120	4290	3660												
1905		2060	1570	1470	1440	1320												
1906		2740	2380	1770	1450	1220												
1907		17000	12800	8240	5260	3310												
1908																		
1909																		
1910																		
1911																		
1912																		
1913																		
1914																		
1915																		
1916																		
1917																		
1918																		
1919								2112	1477	1006	723	620						
1920								1005	783	603	532	492						
1921								2156	1842	1526	1304	1110						
1922								1580	1500	1223	927	767						
1923								1662	1555	1317	1040*	845						
1924								956	846	658	595	522						
1925								3053	2806	1823	1188	827						
1926								829	808	734	706	588						
1927								2430	2035	1927	1584	1337						
1928								12200	11200	8721	4387	2460						
1929								667	533	467	434	388						
1930								1624	1390	1241	866	632						
1931								759	682	590	428	321						
1932								1213	1167	1004	809	560						
1933		250	250	229	203	197		253	248	226	198	191						
1934		1730	1540	1060	836	638		1849	1516	979	763	580						

1927								2430	2035	1927	1584	1337						
1928								12200	11200	8721	4387	2460						
1929								667	533	467	434	388						
1930								1624	1390	1241	866	632						
1931								759	682	590	428	321						
1932								1213	1167	1004	809	560						
1933		250	250	229	203	197		253	248	226	198	191						
1934		1730	1540	1060	836	638		1849	1516	979	763	580						
1935		375	295	253	234	212		303	262	241	226	199						
1936		1620	1520	1370	1160	914		1634	1482	1330	1124	883						
1937		1730	1430	1120	910	710		1868	1628	1086	912	737						
1938		9760	7410	4410	2450	1490		9424	7123	4314	2372	1456						
1939		2031	1531	1188	927	713		1800	1443	1148	904	708						
1940		4920	4624	3713	2210	1499		5418	4849	3671	2161	1492						
1941		1292	1043	874	716	648		1255	1062	874	687	642						
1942		2486	2230	1586	1541	1392		2462	2135	1550	1513	1366						
1943		7852	6001	4251	3493	2958		7909	5998	4388	3565	3019						
1944		655	465	425	412	396		584	441	416	396	379						
1945		2992	2360	1500	1086	815		3085	2298	1580	1113	820						
1946		1110	1051	947	881	809		1346	1226	1025	949	816						
1947		1408	1175	977	778	631		1145	1105	890	537	506						
1948		1106	917	728	544	402		817	735	655	511	392						
1949								365	306	298	269	238						
1950		1528	1303	1020	844	730		1098	1068	935	781	693						
1951		10312	8974	6585	3864	3841		11157	9704	6862	4046	3915						
1952		2844	2792	2460	2211	2026		2981	2843	2576	2374	2177						
1953		2066	1667	1475	1462	1402		2356	2176	2124	2059	1752						
1954		2078	1824	1418	1050	813		2913	2569	1852	1243	901						
1955																		
1956	23200	17332	14434				23000	19809	14703				18100	16196	12395			
1957																		
1958																		
1959		1520	1125	820	651	604												
1960		1945	1545	1172	967	865												
1961		514	470	411	377	354												
1962		836	704	548	401	345												
1963	26800	22299	13847	8317	4554	2697	27000	21403	14606				20400	18179	12866			
1964		1782	1514	1096	970	737												
1965		16666	14545	9746	5437	3335												
1966		2001	1995	1979	1795	1281												
1967		5046	4180	3185	2314	1512		5267	4255	3254	2332	1521		4441	3786	3232	2372	1546
1968		2356	2181	1908	1544	1214		2102	2005	1795	1308	820		2437	2222	1962	1574	1225
1969		4297	3686	2960	2518	2255		3897	2974	2522	2198	1975		3653	3216	2681	2331	2128

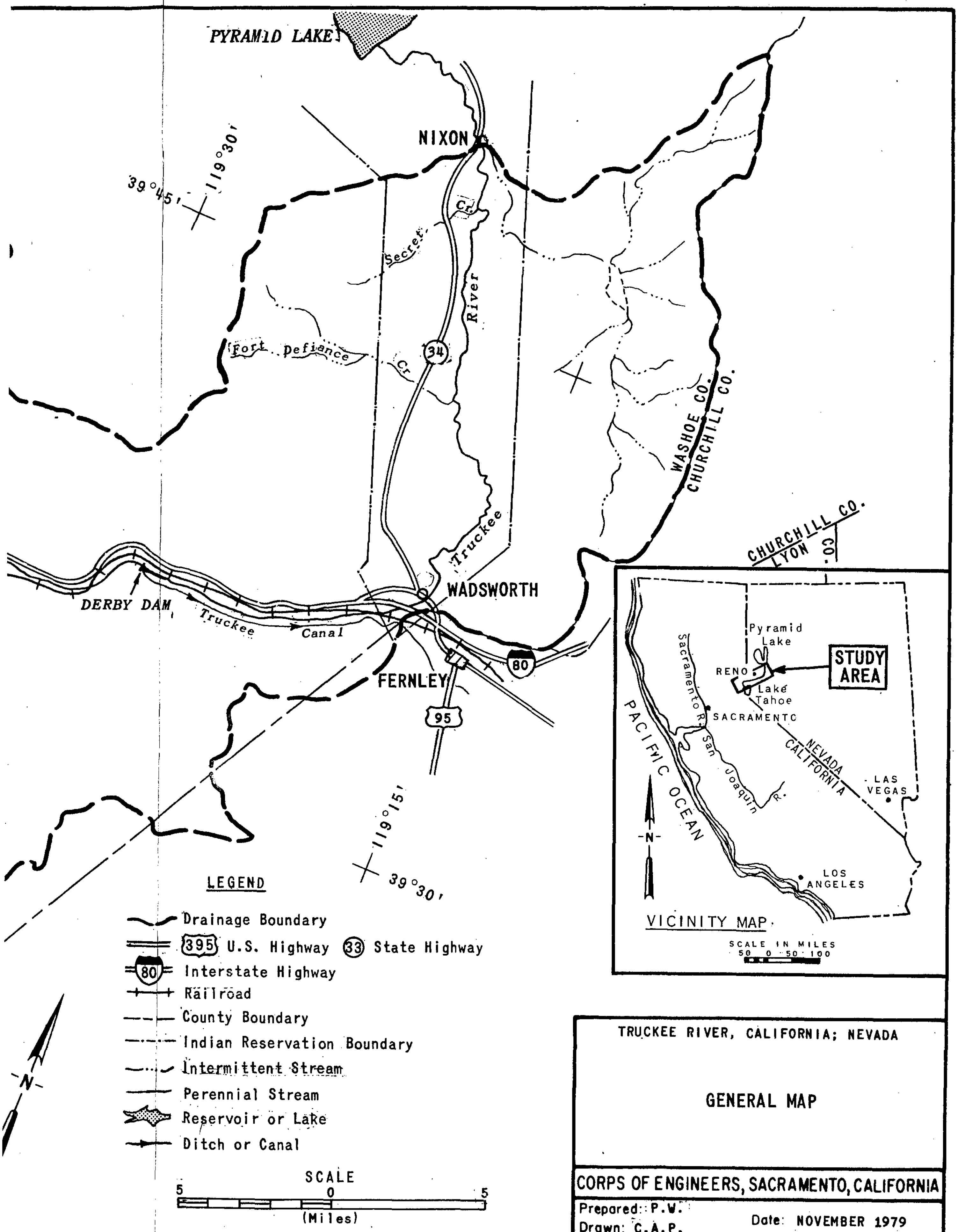
1959		1520	1125	820	651	604												
1960		1945	1545	1172	967	865												
1961		514	470	411	377	354												
1962		836	704	548	401	345												
1963	26800	22299	13847	8317	4554	2697	27000	21403	14606				20400	18179	12866			
1964		1782	1514	1096	970	737												
1965		16666	14545	9746	5437	3335												
1966		2001	1995	1979	1795	1281												
1967		5046	4180	3185	2314	1512		5267	4255	3254	2332	1521		4441	3786	3232	2372	1546
1968		2356	2181	1908	1544	1214		2102	2005	1795	1308	820		2437	2222	1962	1574	1225
1969		4297	3686	2960	2518	2255		3897	2974	2522	2198	1975		3653	3216	2681	2331	2128
1970		9820	8831	7841	5565	4104		9631	7787	6528	4906	3729		10327	8460	7033	5414	3974
1971		1526	1488	1389	1221	1145		1618	1531	1484	1303	1221		1538	1472	1436	1265	1188
1972		1550	1515	1411	1343	1184		1507	1473	1401	1338	1154		1520	1493	1437	1378	1225
1973		1493	1438	1258	911	688		1584	1447	1279	943	702		1607	1474	1305	993	762
1974		4850	4494	3445	2005	1783		4848	4395	3620	1941	1739		4774	4574	3849	2034	1858
1975		1755	1214	947	794	722		1971	1308	1017	854	767		1458	1278	1034	885	795
1976		1130	828	689	575	555		982	853	703	577	531		782	768	708	590	557
1977		770	680	556	479	445		700	625	526	472	436		735	654	574	500	462
COMPUTED STATISTICS																		
Years Record		48	48	47	47	47		49	49	47	47	47		13	13	11	11	11
Log Mean		3.392	3.317	3.197	3.095	3.009		3.305	3.238	3.111	3.006	2.919		3.481	3.426	3.247	3.149	3.075
Log Std. Dev.		.439	.430	.389	.349	.322		.435	.421	.360	.322	.305		.464	.430	.326	.297	.271
Skew		.317	.255	.174	.001	.002		.421	.346	.194	.072	.183		.474	.358	.297	.325	.313
EXTENDED STATISTICS BASED ON MULTIPLE CORRELATION																		
Equiv. Years Record		76.6	76.9	76.8	76.7	76.7		75.9	76.8	76.7	76.4	76.4		76.3	76.9	76.9	76.9	76.9
Log Mean		3.343	3.263	3.166	3.072	2.984		3.325	3.259	3.171	3.059	2.970		3.313	3.264	3.194	3.083	2.997
Log Std. Dev.		.402	.397	.371	.330	.300		.418	.404	.378	.334	.310		.388	.377	.360	.308	.281
Skew		.520	.452	.377	.209	.190		.466	.418	.380	.214	.184		.549	.511	.524	.320	.323
ADOPTED STATISTICS																		
Equiv. Years Record		77	77	77	77	77		76	77	77	76	76		76	77	77	77	77
Log Mean		3.343	3.263	3.166	3.072	2.984		3.325	3.259	3.171	3.059	2.970		3.313	3.264	3.194	3.083	2.997
Log Std. Dev.		.39	.39	.37	.34	.32		.39	.38	.36	.34	.32		.38	.36	.34	.32	.30
Skew		.5	.4	.3	.2	.1		.5	.4	.3	.2	.1		.5	.4	.3	.2	.1



120°30'
39°30'
MTNS
WEBBER LAKE
Little
Truckee
120°15'
CALIFORNIA
NEVADA
STAMPEDE RES.
NEVADA
INDEPENDENCE LAKE
Sagehen Cr.
River
VERDI
89
Prosser
Creek
SIERRA CO.
NEVADA CO.
Southern Pacific
Alder Creek
PROSSER CR. RES.
BOCA RES.
Donner Cr.
DONNER LAKE
FARAD
WASHOE CO.
Hunter
TRUCKEE
80
River
SIERRA
89
Thomas
39°15'
MARTIS CR. LAKE
Martis Cr.
NEVADA CO.
PLACER CO.
Mt. Rose
Galena Creek
Squaw Creek
Truckee
Ophir Creek
28
Cr.
Franktown
TAHOE CITY
LAKE TAHOE
WASHOE
CARSON CITY
CARSON CITY

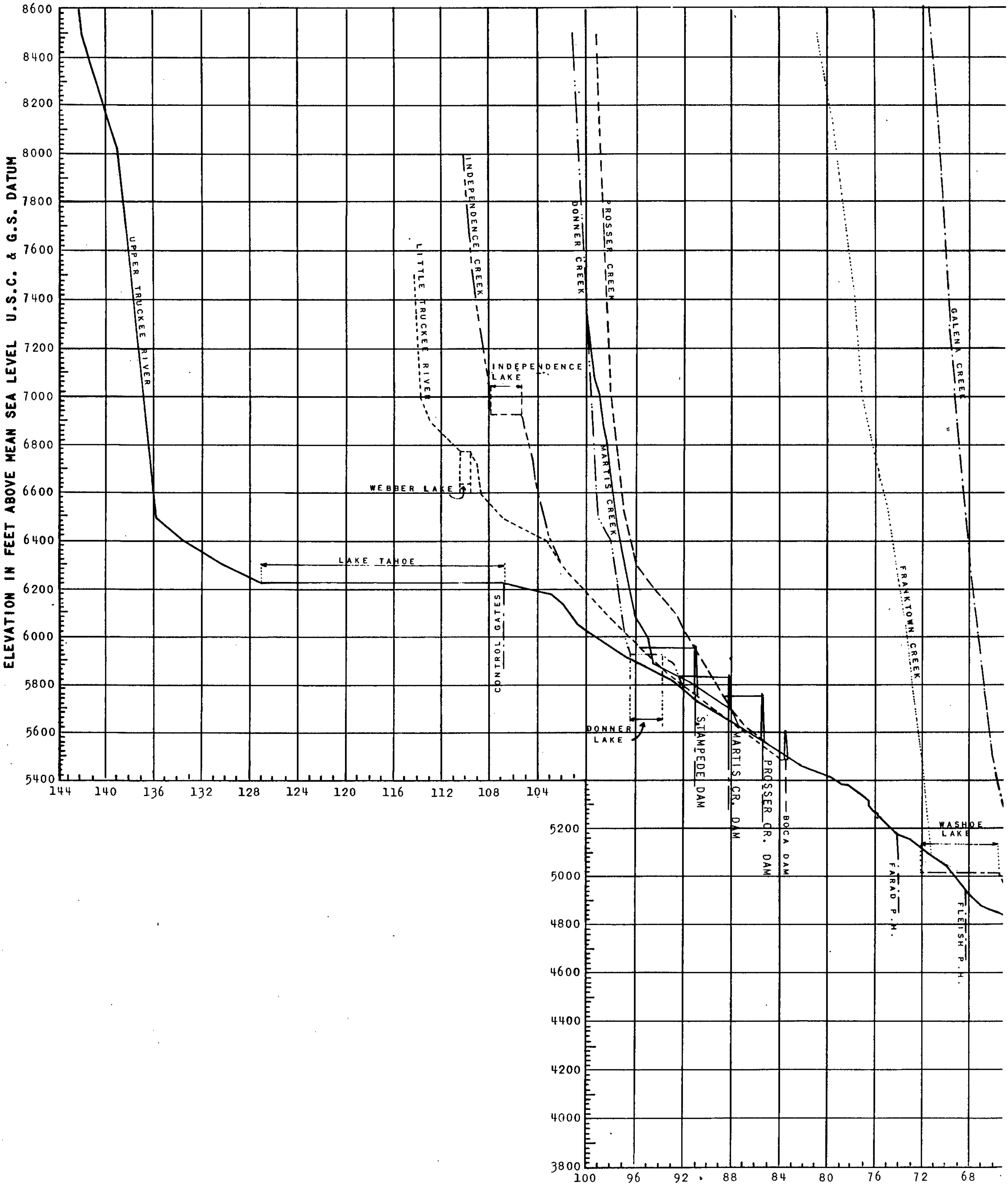


PYRAMI
CALIFORNIA
NEVADA
120°00'
119°45'
119°30'
39°45'
VERDI
LAWTON
Peavine Cr.
W. Wash
E. Wash
395
Sun Valley
Spanish Springs Valley
Drain
Fort
SPARKS
Truckee
RENO
VISTA
Truckee
Creek
Hunter
Evans Cr
Boynton Sl.
Cr
River
WASHOE CO.
STOREY CO
DERBY DAM
Truckee
Steamboat
Dry Creek
Thomas
Huffaker Hills
Truckee Meadows
CO.
CO.
Creek
Whites
Creek
Ditch
27
Creek
Steamboat
WASHOE
STOREY
Cr.
Creek
Lousetown
Valley
Long
Bailey Can.
Creek
WASHOE LAKE
STOREY CO
LYON CO
CO.
CO.
39°15'
50
ITY
N
LEGENI
Drainage
395 U.S.
80 Interstat
Railroad
County Bo
Indian Re
Intermitt
Perennial
Reservoir
Ditch or
5

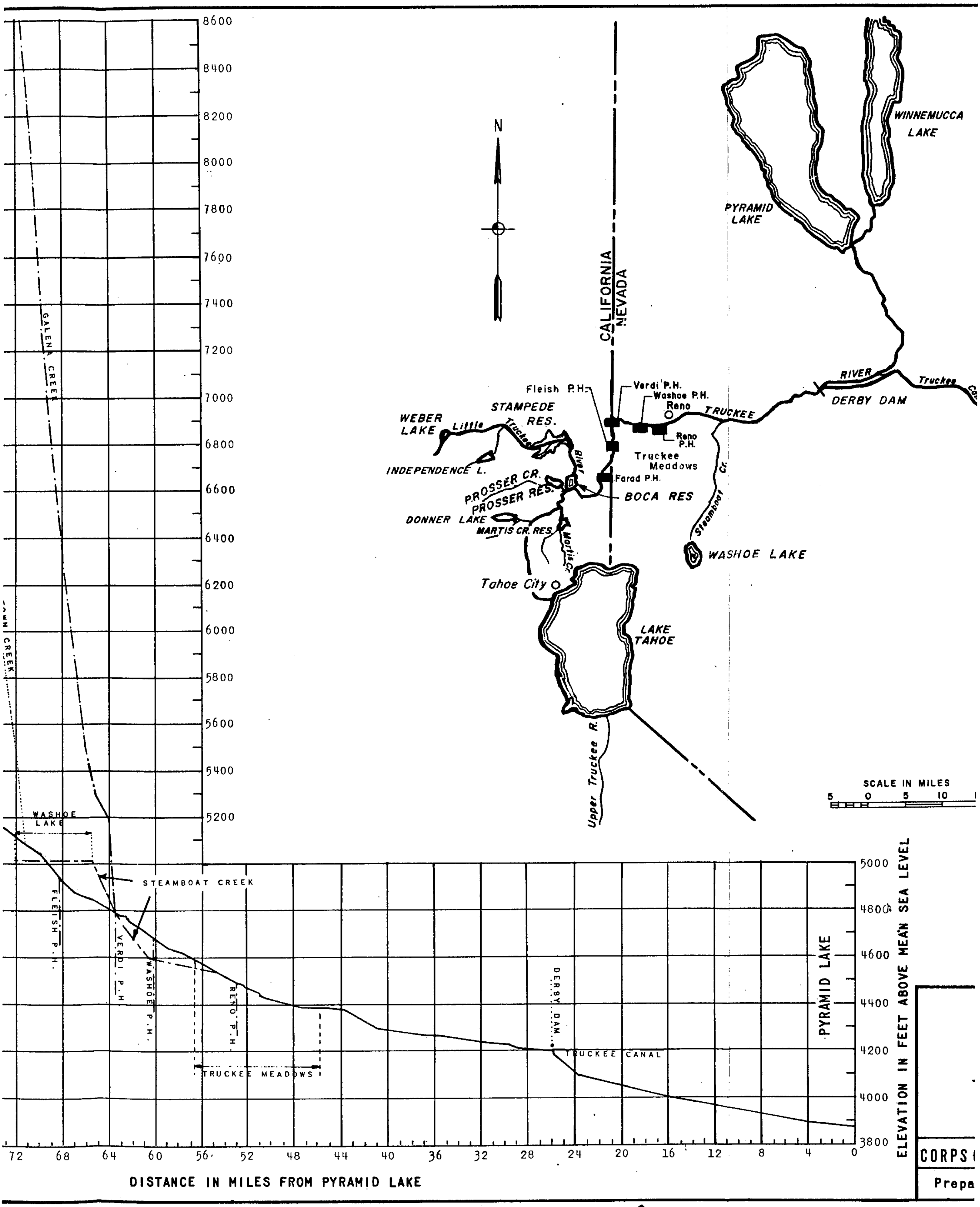


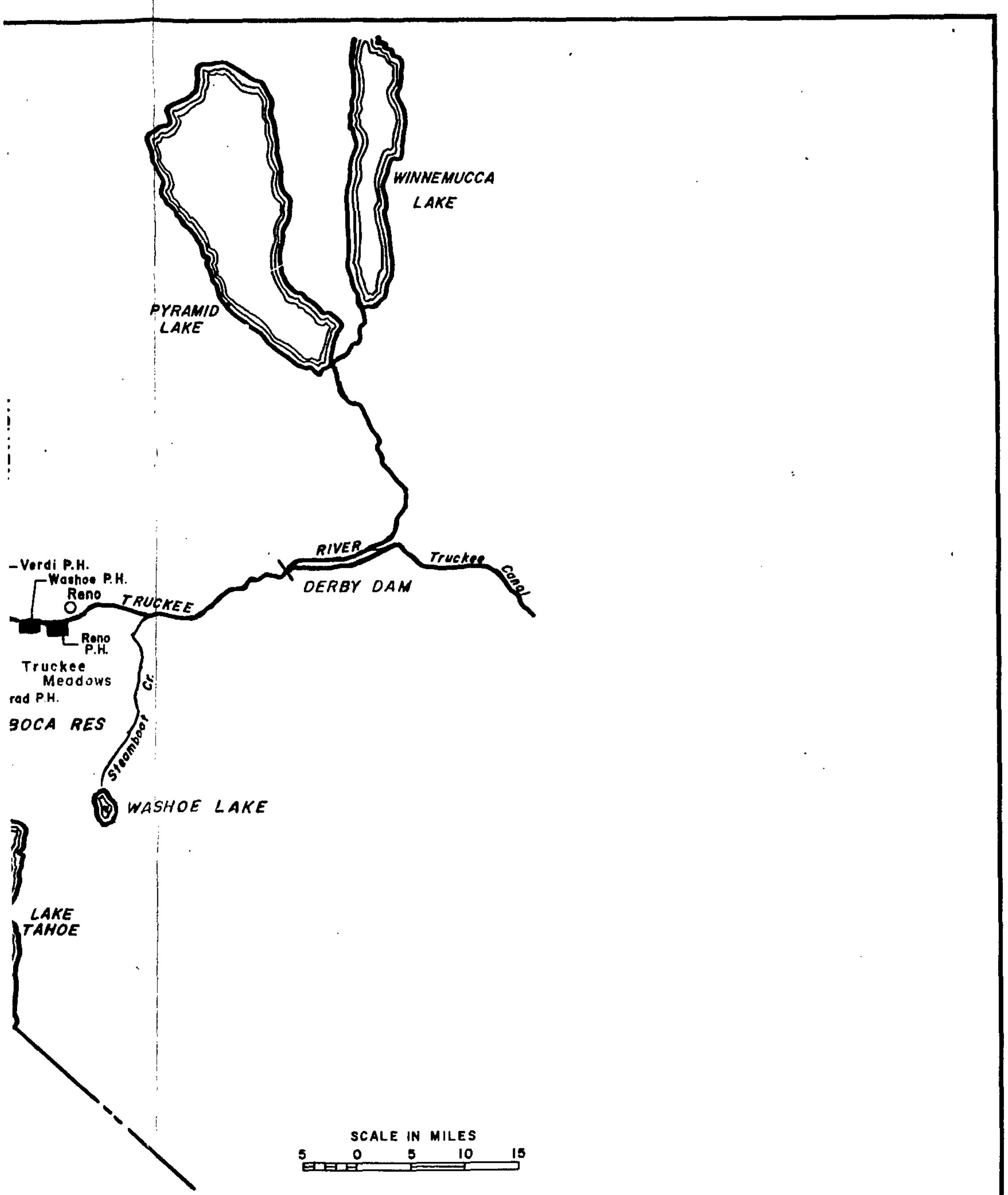
PYRAMID LAKE
NIXON
39°45'
119°30'
Secret Cr.
River
Truckee
Fort Defiance Cr
34
WASHOE CO.
CHURCHILL CO.
CHURCHILL CO.
LYON CO.
DERBY DAM
Truckee Canal
WADSWORTH
FERNLEY
80
95
119°15'
39°30'
Pyramid Lake
STUDY AREA
RENO
Lake Tahoe
Sacramento R.
SACRAMENTO
San Joaquin R.
PACIFIC OCEAN
NEVADA
CALIFORNIA
LAS VEGAS
LOS ANGELES
N
VICINITY MAP
SCALE IN MILES
50 0 50 100
LEGEND
Drainage Boundary
395 U.S. Highway
33 State Highway
80 Interstate Highway
Railroad
County Boundary
Indian Reservation Boundary
Intermittent Stream
Perennial Stream
Reservoir or Lake
Ditch or Canal
N
SCALE
5 0 5
(Miles)
TRUCKEE RIVER, CALIFORNIA; NEVADA
GENERAL MAP
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: P.W.
Drawn: C.A.P.
Date: NOVEMBER 1979

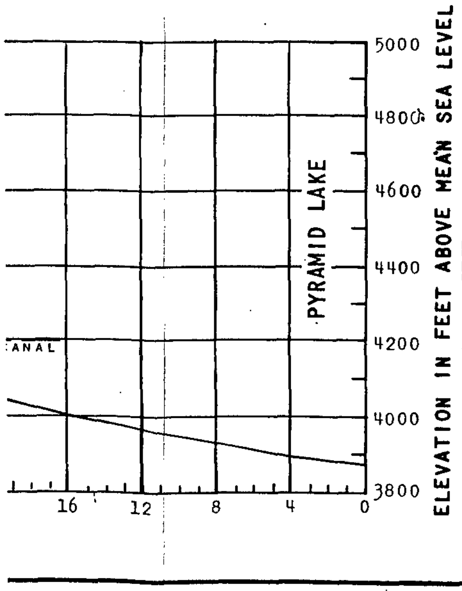
CHART I



ELEVATION IN FEET ABOVE MEAN SEA LEVEL U.S.C. & G.S. DATUM
8600
8400
8200
8000
7800
7600
7400
7200
7000
6800
6600
6400
6200
6000
5800
5600
5400
5200
5000
4800
4600
4400
4200
4000
3800
144
140
136
132
128
124
120
116
112
108
104
100
96
92
88
84
80
76
72
68
UPPER TRUCKEE RIVER
LITTLE TRUCKEE RIVER
INDEPENDENCE CREEK
INDEPENDENCE LAKE
DONNER CREEK
PROSSER CREEK
MARTIS CREEK
GALENA CREEK
FRANKTOWN CREEK
WEBBER LAKE
LAKE TAHOE
CONTROL GATES
DONNER LAKE
STAMPEDE DAM
MARTIS CR. DAM
PROSSER CR. DAM
BOCA DAM
WASHOE LAKE
FARAD P.H.
FLEISH P.H.


N
CALIFORNIA
NEVADA
WINNEMUCCA LAKE
PYRAMID LAKE
RIVER
Truckee
DERBY DAM
TRUCKEE
Fleish P.H.
Verdi P.H.
Washoe P.H.
Reno
Reno P.H.
Truckee Meadows
STAMPEDE RES.
WEBER LAKE
Little Truckee
INDEPENDENCE L.
River
Farad P.H.
PROSSER CR.
PROSSER RES.
BOCA RES
Steamboat Cr.
DONNER LAKE
MARTIS CR. RES.
Martis Cr.
WASHOE LAKE
Tahoe City
LAKE TAHOE
Upper Truckee R.
SCALE IN MILES
5 0 5 10
8600
8400
8200
8000
7800
7600
7400
7200
7000
6800
6600
6400
6200
6000
5800
5600
5400
5200
5000
4800
4600
4400
4200
4000
3800
GALENA CREEK
CREEK
WASHOE LAKE
STEAMBOAT CREEK
FLEISH P.H.
VERDI P.H.
WASHOE P.H.
RENO P.H.
DERBY DAM
TRUCKEE CANAL
TRUCKEE MEADOWS
PYRAMID LAKE
72 68 64 60 56 52 48 44 40 36 32 28 24 20 16 12 8 4 0
DISTANCE IN MILES FROM PYRAMID LAKE
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
CORPS
Prepa





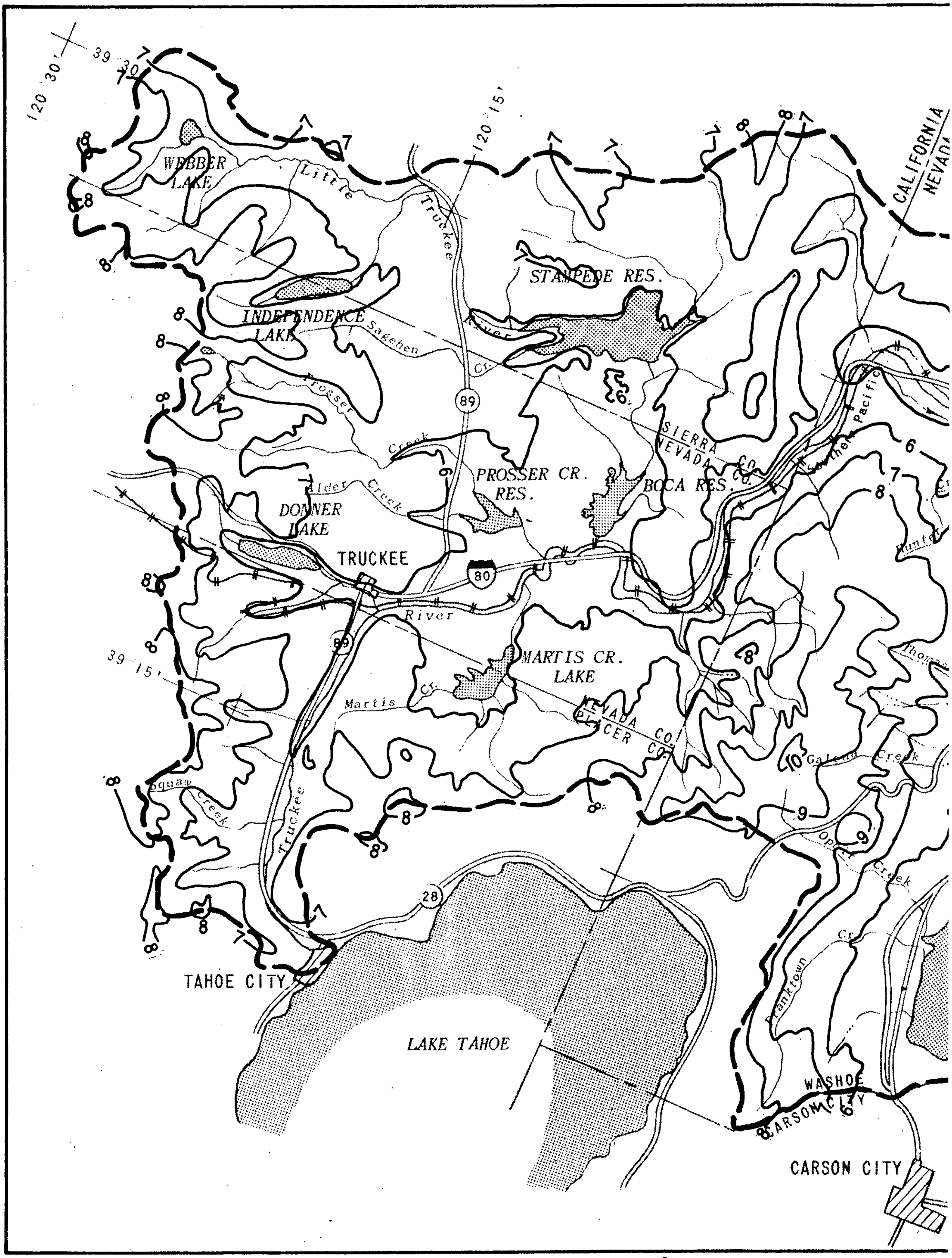
TRUCKEE RIVER, CALIFORNIA; NEVADA

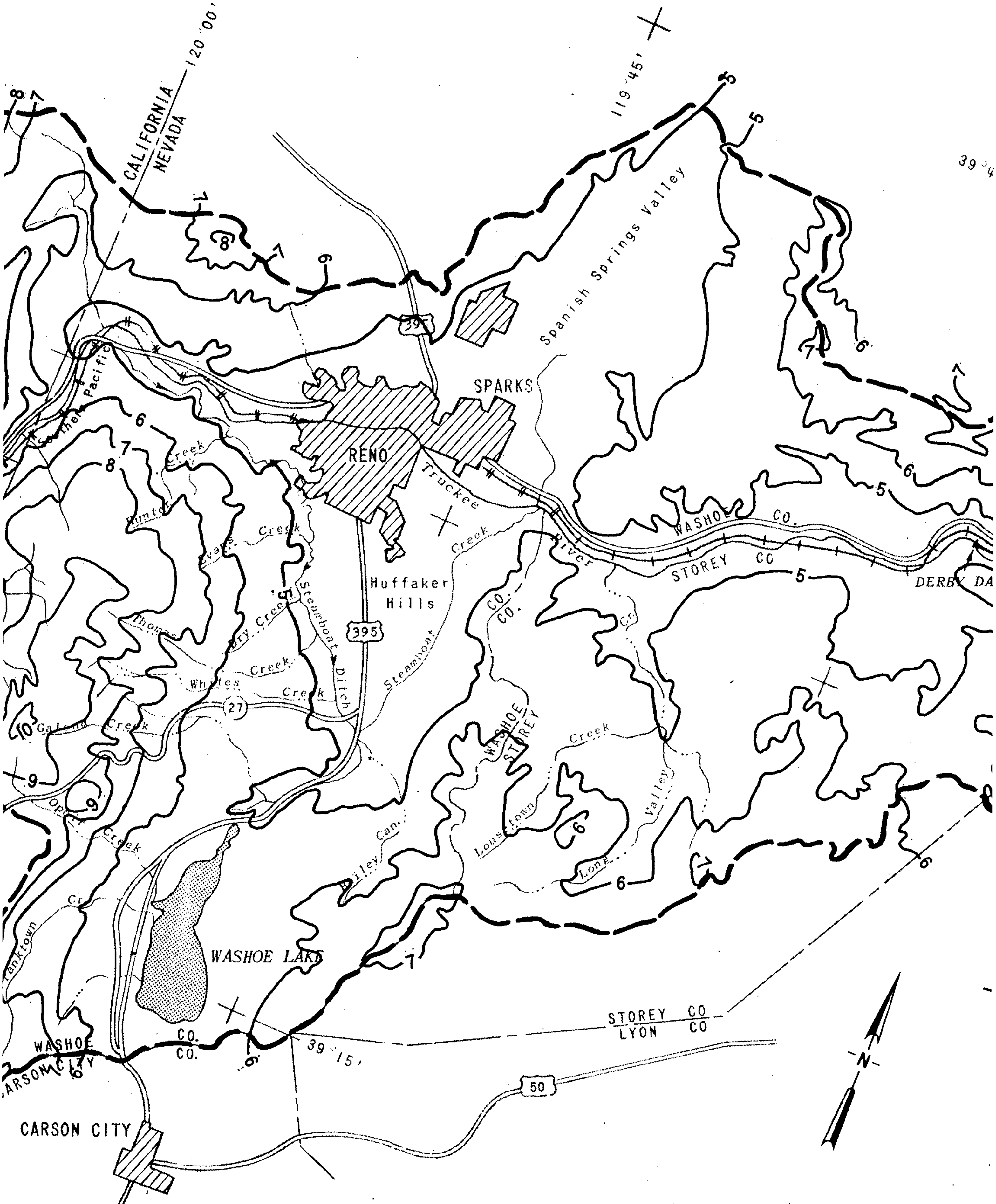
STREAM BED PROFILES
TRUCKEE RIVER AND TRIBUTARIES

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

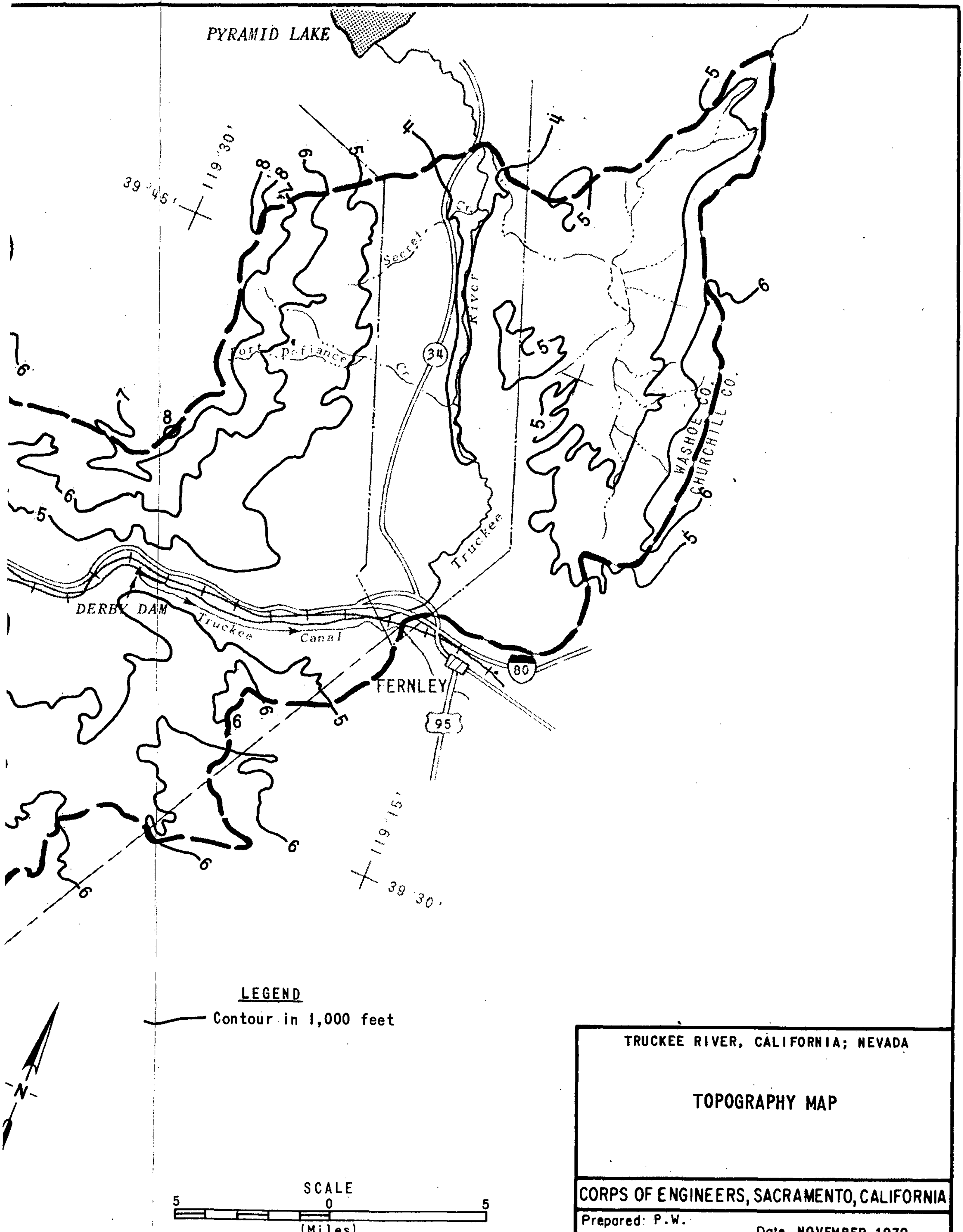
Prepared: J.H. Date: NOVEMBER 1979

CHART 2


WEBBER LAKE
INDEPENDENCE LAKE
STAMPEDE RES.
PROSSER CR. RES.
BOCA RES.
DONNER LAKE
TRUCKEE
MARTIS CR. LAKE
LAKE TAHOE
TAHOE CITY
CARSON CITY
SIERRA CO.
NEVADA CO.
PLACER CO.
WASHOE
CARSON CITY
CALIFORNIA
NEVADA
Little Truckee River
Sagehen Cr.
Prosser Creek
Alder Creek
River
Martis Cr.
Squaw Creek
Truckee
Galena Creek
Ophir Creek
Franktown Cr.
Southern Pacific
Hunter
Thomas
89
80
28
120°30'
120°15'
39°30'
39°15'



CALIFORNIA
NEVADA
120°00'
119°45'
Spanish Springs Valley
SPARKS
RENO
Truckee
River
Creek
Huffaker
Hills
WASHOE CO.
STOREY CO
DERBY DA
Southern Pacific
Hunter
Creek
Evans
Thomas
Dry Creek
Steamboat
Ditch
Whites
Galena
Creek
Ophir
Franktown
WASHOE LAKE
Lousetown
Long
Valley
Bailey Can.
WASHOE
STOREY
STOREY CO
LYON CO
39°15'
WASHOE CO.
CARSON CITY CO.
CARSON CITY
395
27
50
N



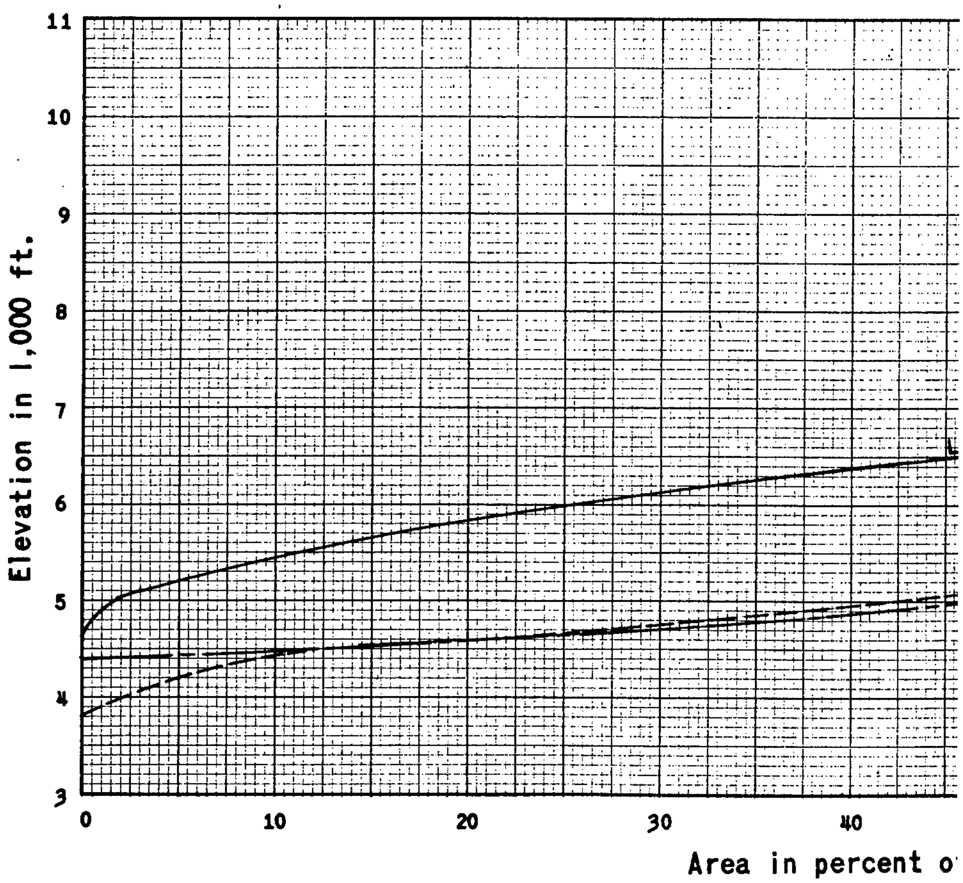
TRUCKEE RIVER, CALIFORNIA; NEVADA

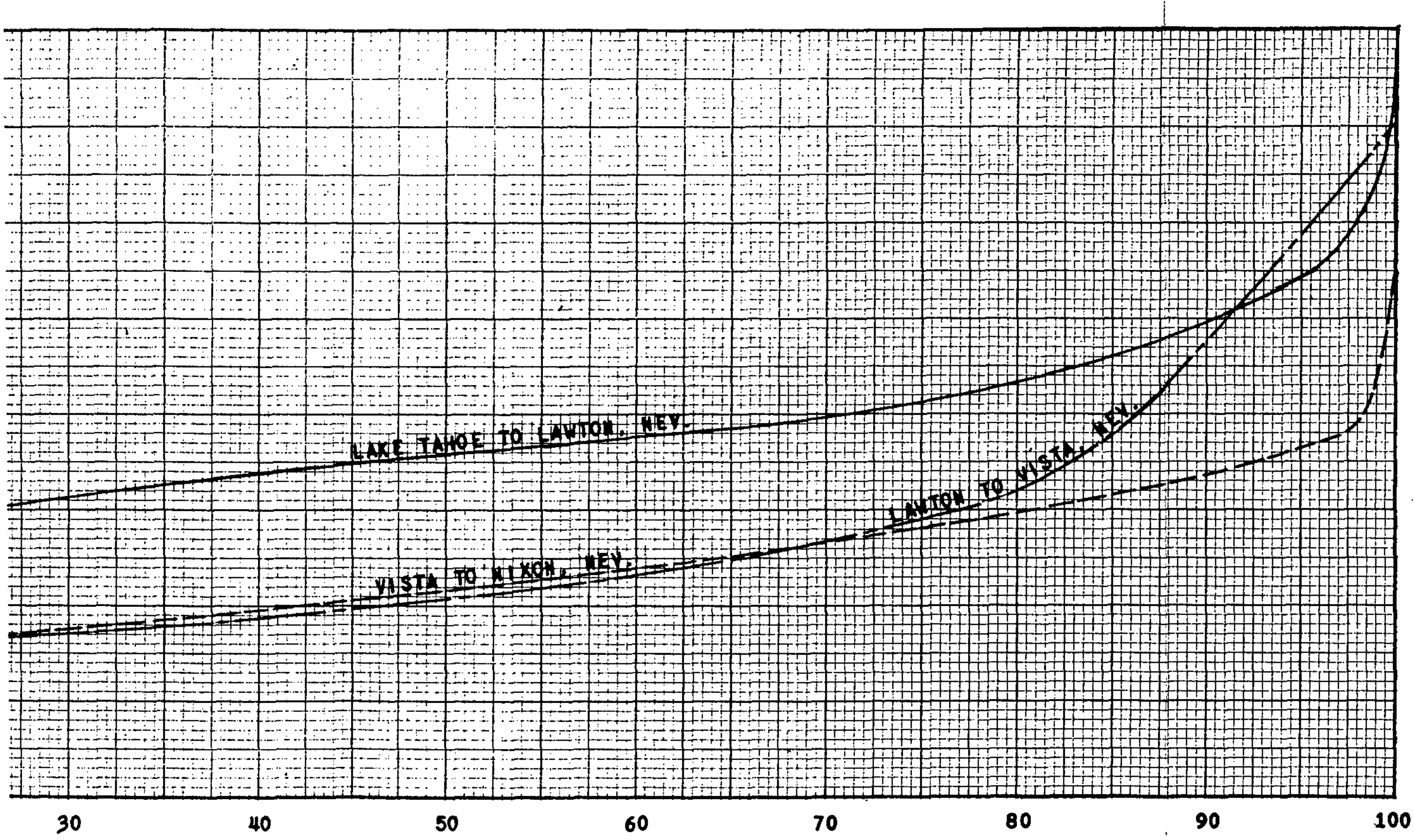
TOPOGRAPHY MAP

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: C.A.P.

Date NOVEMBER 1979


Elevation in 1,000 ft.
11
10
9
8
7
6
5
4
3
0
10
20
30
40
Area in percent o



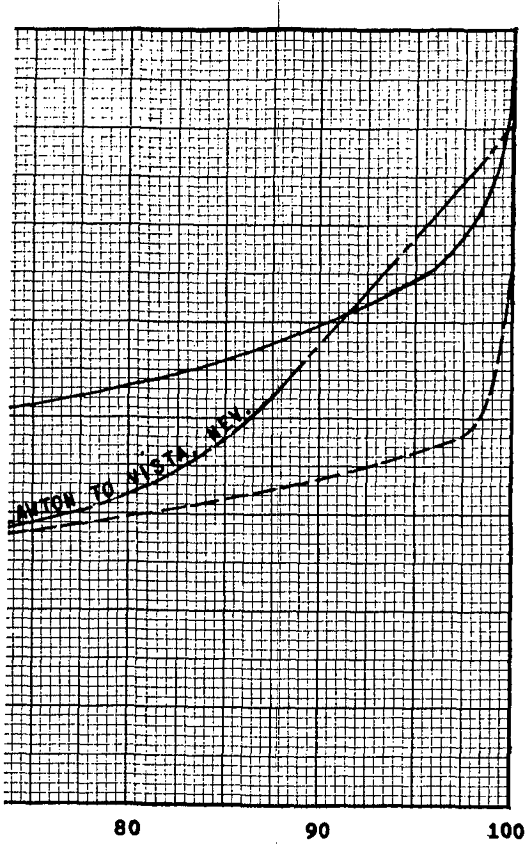
Area in percent of area below given elevation

TRUCKEE RIVER,

AREA ELE

CORPS OF ENGINEER

Prepared: P.W.
Drawn: J.H.



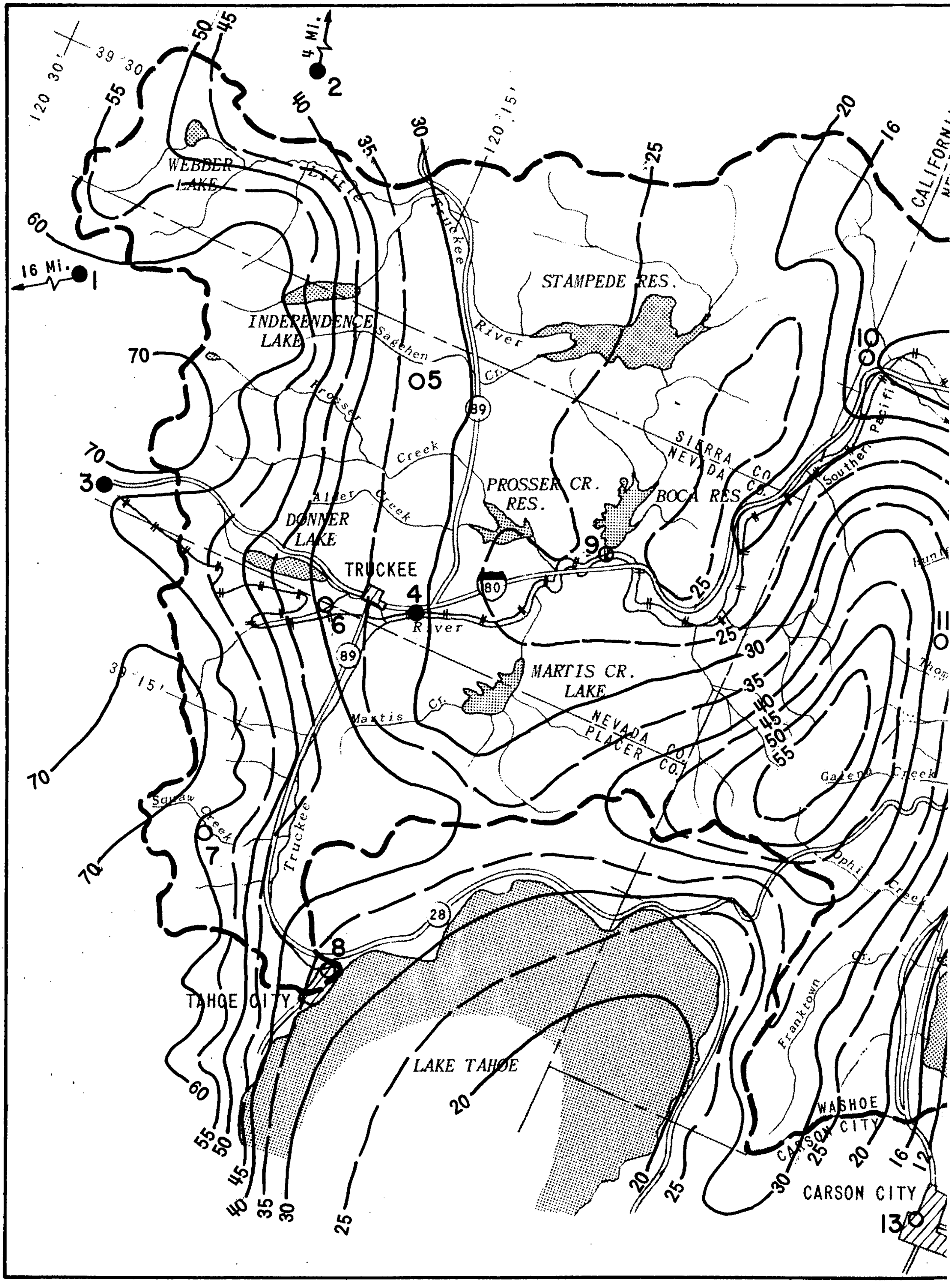
TRUCKEE RIVER, CALIFORNIA; NEVADA

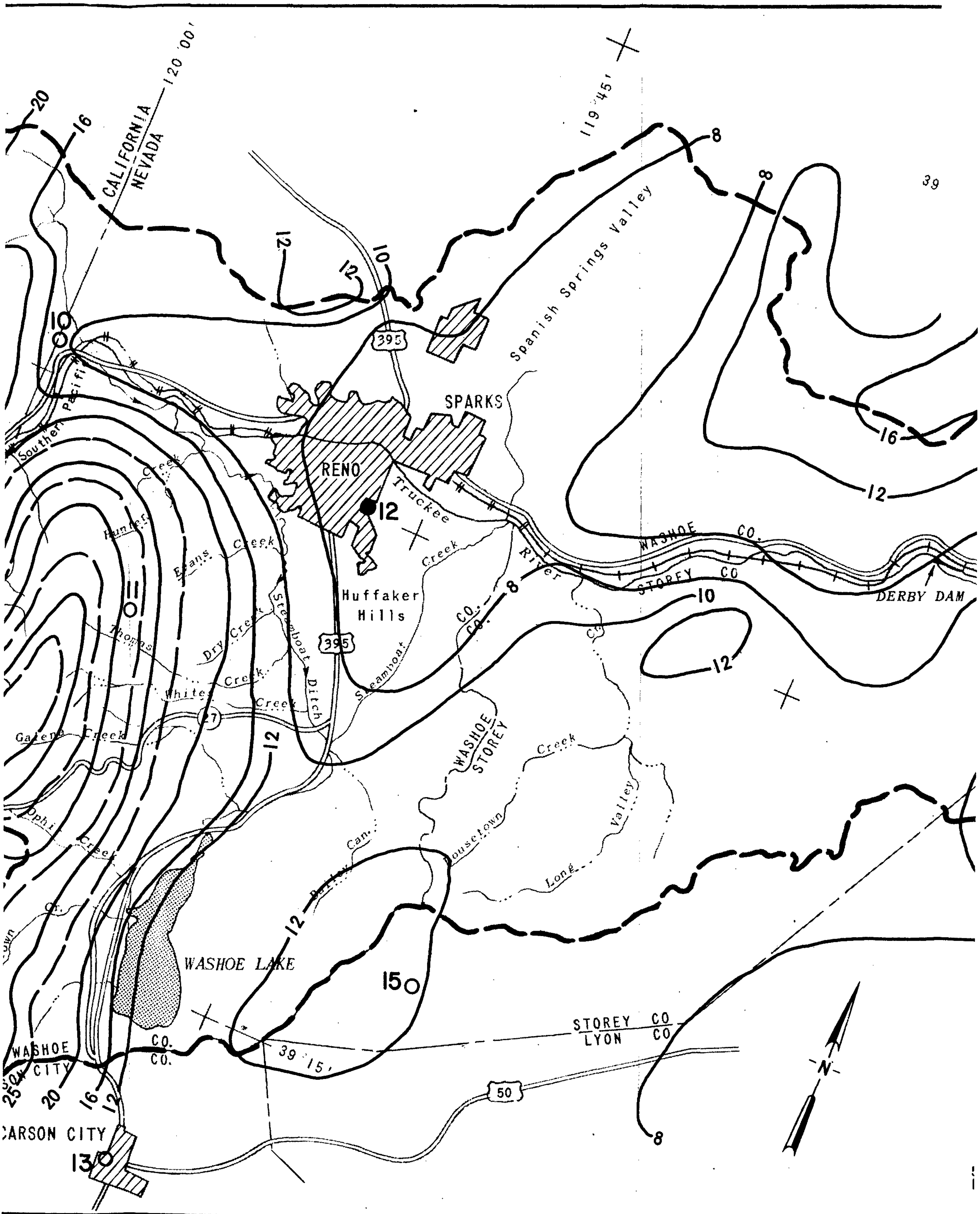
AREA ELEVATION CURVES

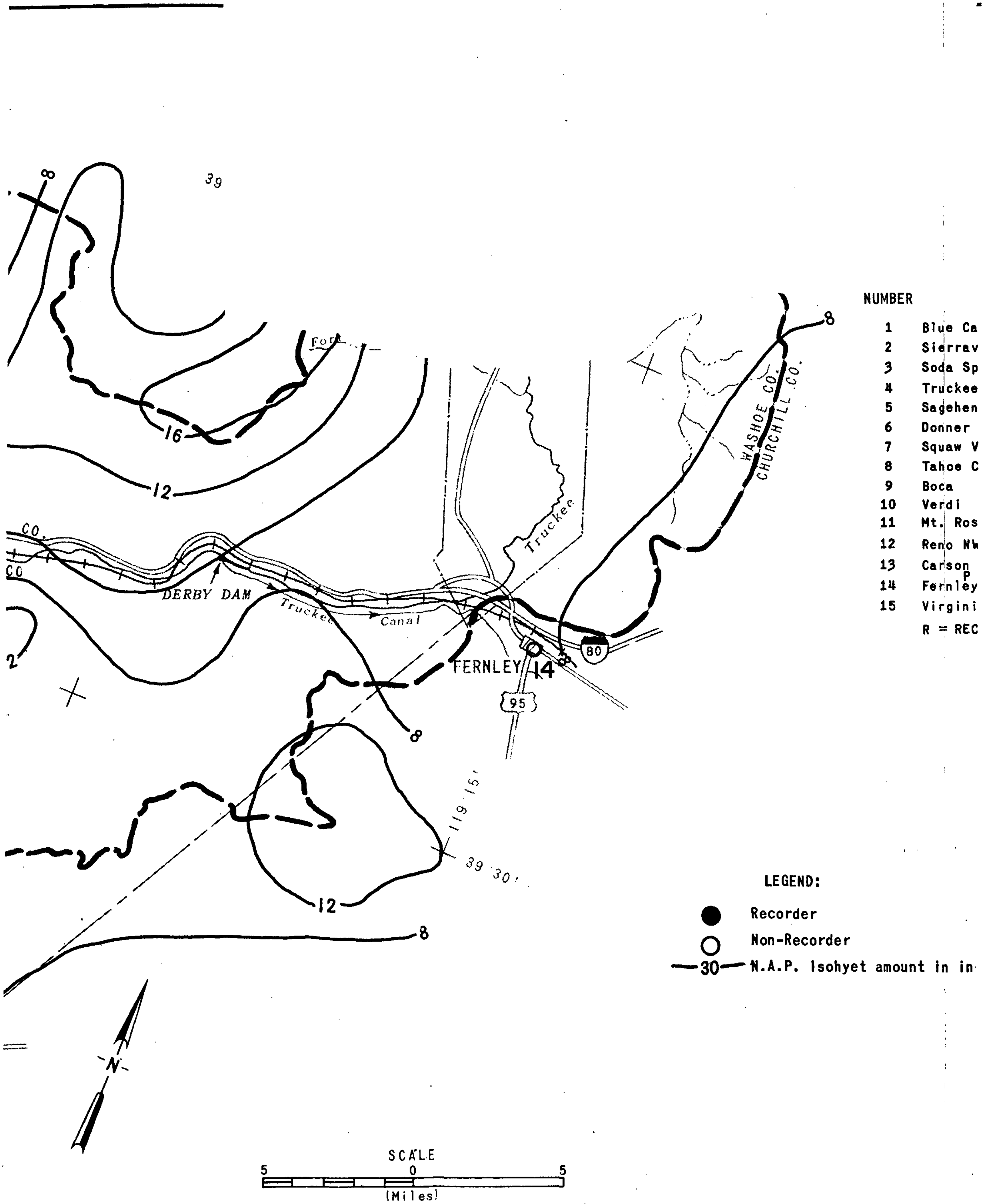
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: J.H.
Date: NOVEMBER 1979

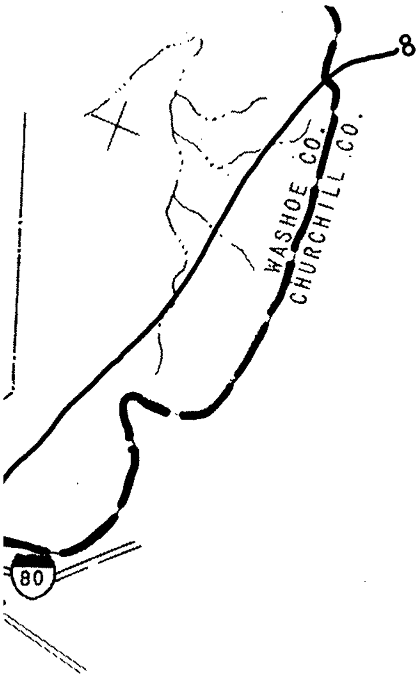
CHART 4


WEBBER LAKE
Little Truckee River
INDEPENDENCE LAKE
Sagehen Cr.
STAMPEDE RES.
Prosser Creek
PROSSER CR. RES.
BOCA RES.
SIERRA CO.
NEVADA CO.
Alder Creek
DONNER LAKE
TRUCKEE
River
MARTIS CR. LAKE
Martis Cr.
NEVADA CO.
PLACER CO.
Squaw Creek
Truckee
TAHOE CITY
LAKE TAHOE
Galena Creek
Ophir Creek
Franktown Cr.
WASHOE
CARSON CITY
CARSON CITY
CALIFORNIA
Southern Pacific
16 Mi.
4 Mi.
120 30'
39 30'
120 15'
39 15'


CALIFORNIA
NEVADA
120°00'
119°45'
39
Spanish Springs Valley
SPARKS
RENO
Truckee River
Huffaker Hills
Southern Pacific
Hunter Creek
Evans Creek
Thomas Creek
Dry Creek
White Creek
Steamboat Ditch
Steamboat Creek
Galena Creek
Ophir Creek
WASHOE LAKE
WASHOE CO.
STOREY CO.
WASHOE
STOREY
DERBY DAM
Long Valley
STOREY CO
LYON CO
CARSON CITY
39°15'
395
27
50
N



39
16
12
8
Fork
Truckee
WASHOE CO.
CHURCHILL CO.
CO.
CO
DERBY DAM
Truckee
Canal
FERNLEY
14
80
95
2
119°15'
39°30'
12
8
N
SCALE
5
0
5
(Miles)
NUMBER
1 Blue Ca
2 Sierrav
3 Soda Sp
4 Truckee
5 Sagehen
6 Donner
7 Squaw V
8 Tahoe C
9 Boca
10 Verdi
11 Mt. Ros
12 Reno Nw
13 Carson
14 Fernley P
15 Virgini
R = REC
LEGEND:
Recorder
Non-Recorder
30 N.A.P. Isohyet amount in in



PRECIPITATION STATIONS

NUMBER	STATION		N.A.P. (IN.)	YEARS OF RECORD
1	Blue Canyon AP	R	65.0	39
2	Sierraville R.S.	R	27.8	96
3	Soda Springs I.E.	R	61.4	19
4	Truckee R.S.	R	32.8	96
5	Sagehen	N	32.1E	25
6	Donner Memorial St. Park	N	39.2	25
7	Squaw Valley Lodge	N	59.0E	19
8	Tahoe City	N	34.1	69
9	Boca	N	20.4	89
10	Verdi	N	11.5E	5
11	Mt. Rose Highway Station	N	37.0E	4
12	Reno NWS AP	R	7.2	109
13	Carson City	N	11.5	82
14	Fernley	N	8.7E	20
15	Virginia City	N	12.0E	38

R = RECORDER; N = NON-RECORDER

LEGEND:

● Recorder

○ Non-Recorder

—30— N.A.P. Isohyet amount in inches

TRUCKEE RIVER, CALIFORNIA; NEVADA

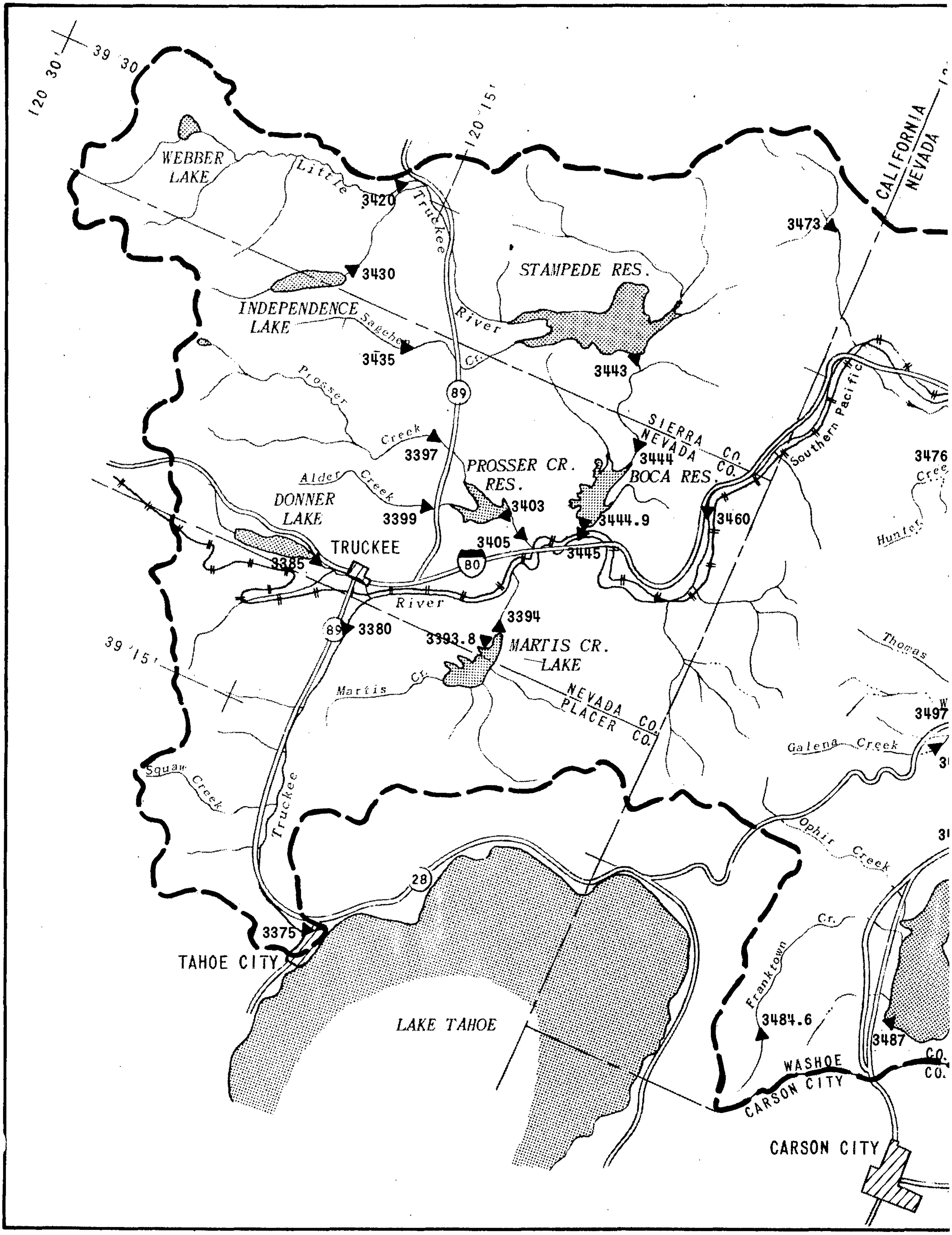
NORMAL ANNUAL PRECIPITATION MAP

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

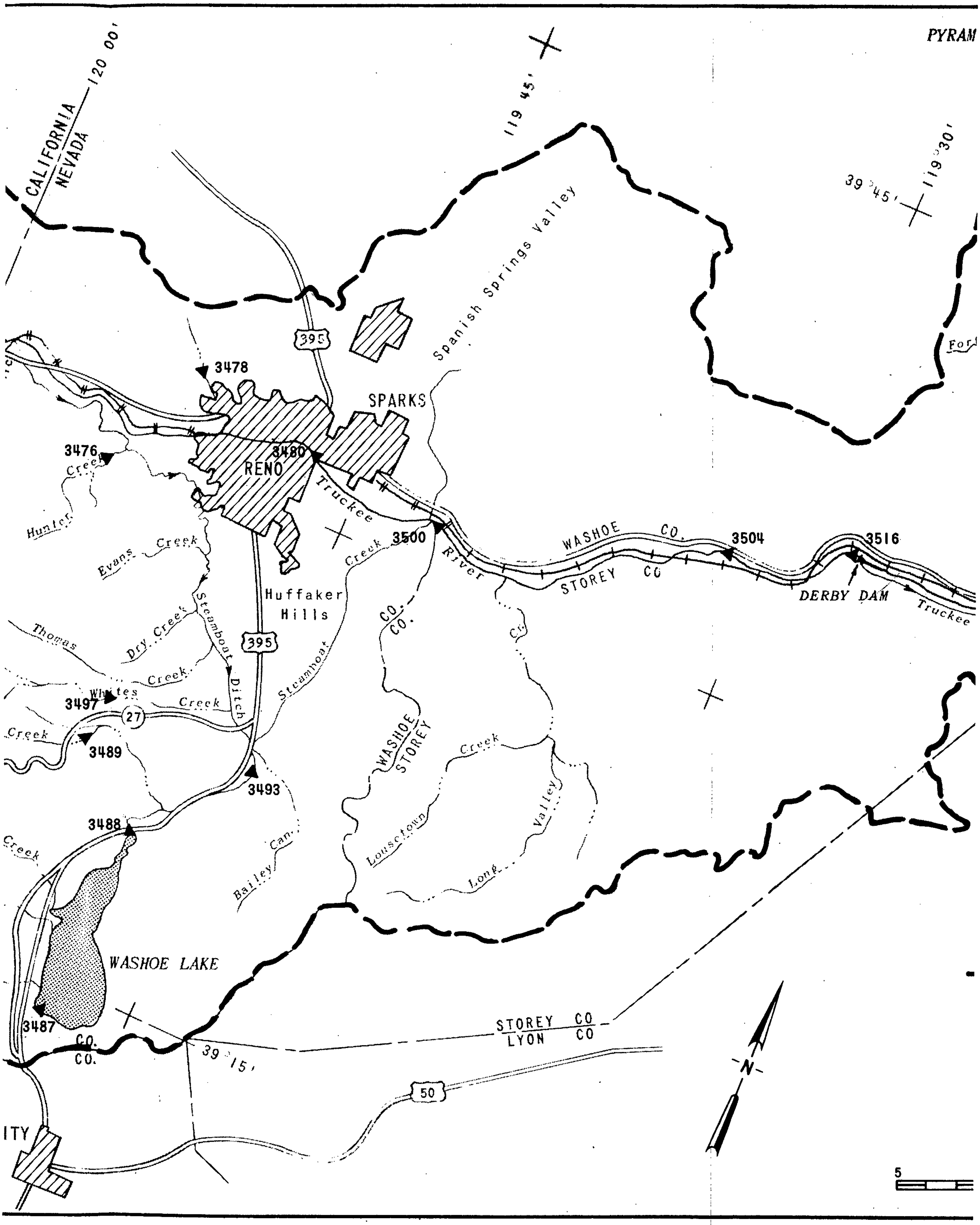
Prepared: P.W.
Drawn: C.A.P.

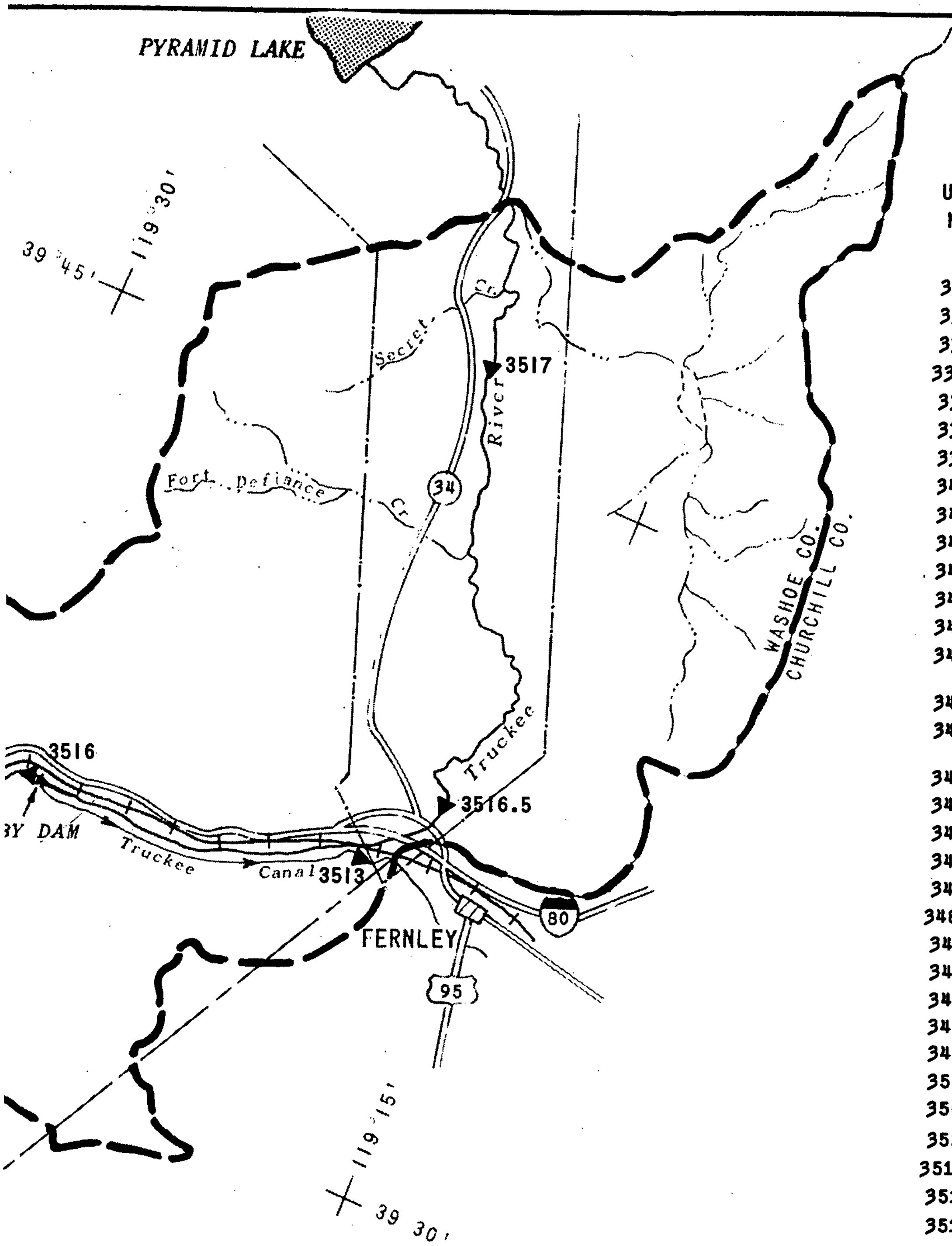
Date NOVEMBER 1979

CHART 5



120 30'
39 30'
120 15'
WEBBER LAKE
Little Truckee River
3420
3430
INDEPENDENCE LAKE
Sagehen Cr.
3435
STAMPEDE RES.
3443
3473
CALIFORNIA
NEVADA
Prosser Creek
3397
89
PROSSER CR. RES.
SIERRA CO.
NEVADA CO.
3444
BOCA RES.
Southern Pacific
3476
Alder Creek
DONNER LAKE
3399
3403
3444.9
3460
TRUCKEE
3405
80
3445
3385
River
3394
3380
3393.8
MARTIS CR. LAKE
39 15'
Martis Cr.
NEVADA CO.
PLACER CO.
Thomas
Hunter
3497
Galena Creek
Squaw Creek
Truckee
Ophir Creek
28
3375
TAHOE CITY
LAKE TAHOE
Franktown Cr.
3484.6
3487
WASHOE CO.
CARSON CITY CO.
CARSON CITY


PYRAM
CALIFORNIA
NEVADA
120 00'
119 45'
119 30'
39 45'
Spanish Springs Valley
395
3478
SPARKS
3476
Creek
3480
RENO
Hunter
Truckee
Evans Creek
3500
Creek
River
WASHOE CO.
STOREY CO
3504
3516
DERBY DAM
Truckee
Huffaker Hills
CO.
CO.
Steamboat Ditch
Thomas
Dry Creek
Creek
Whites
Creek
Steamboat
3497
27
Creek
3489
WASHOE
STOREY
Creek
3493
3488
Creek
Can.
Bailey
Lousetown
Long
Valley
WASHOE LAKE
3487
CO.
CO.
STOREY CO
LYON CO
39 15'
50
N
ITY
5



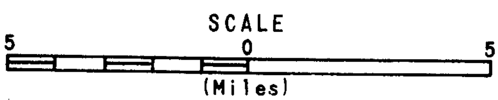
USGS NO.	NAME OF STATION
3375	Truckee River at Tahoe City
3380	Truckee River near Truckee
3385	Donner Creek at Donner Lake n
33938	Martis Creek Lake near Trucke
3394	Martis Creek near Truckee
3397	Prosser Creek near Hobart Mil
3399	Alder Creek near Truckee
3403	Prosser Creek Reservoir near
3405	Prosser Creek near Truckee
3420	Little Truckee River near Hob
3430	Independence Creek near Truck
3435	Sagehen Creek near Truckee
3443	Stampede Reservoir near Boca
3444	Little Truckee River above Bo Reservoir near Boca
3449	Boca Reservoir near Truckee
3445	Little Truckee River below Bo near Truckee
3460	Truckee River at Farad
3473	Dog Creek near Verdi
3476	Hunter Creek near Reno
3478	Peavine Creek near Reno
3480	Truckee River at Reno
34846	Franktown Creek near Carson Ci
3487	Washoe Lake near Carson City
3488	Little Washoe Lake near Steamb
3489	Galena Creek near Steamboat
3493	Steamboat Creek at Steamboat
3497	Whites Creek near Steamboat
3500	Truckee River near Vista
3504	Truckee River below Tracy
3516	Truckee River below Derby Dam
35165	Truckee River at Wadsworth
3517	Truckee River near Nixon
3513	Truckee Canal near Wadsworth

*Broken Record

LEGEND:

Drainage Boundary.

▲ Stream Gaging Station- Refer to Table 5. for List of Stations.



STREAM GAGING STATIONS

NAME OF STATION	DRAINAGE AREA (Sq. Mi.)	ELEVATION GAGE (Ft.)	PERIOD OF RECORD (Water Years) FROM	TO	YEARS
·uckee River at Tahoe City	506	6,216.75	1896, 1901	Present	79
·uckee River near Truckee	552	5,860	1945	1961	17
›nner Creek at Donner Lake near Truckee	14.6	5,930	1910	Present	43*
ırtis Creek Lake near Truckee	40.0	5,780.88	1972	Present	6
.rtis Creek near Truckee	40.0	5,730	1959	Present	19
·osser Creek near Hobart Mills	27.4	5,840	1959	1963	5
der Creek near Truckee	7.36	5,800	1959	1973	13
·osser Creek Reservoir near Truckee	50.5	--	1963	Present	16
·osser Creek near Truckee	53.2	5,602.31	1943	Present	35*
ttle Truckee River near Hobart Mills	36.5	6,290	1947	1972	26
dependence Creek near Truckee	7.63	6,940	1969	Present	10
gehen Creek near Truckee	10.8	6,320	1954	Present	25
ampede Reservoir near Boca	136	--	1970	Present	9
ttle Truckee River above Boca Reservoir near Boca	146	5,618.67	1940	Present	39
ca Reservoir near Truckee	172	--	1939	Present	40
ttle Truckee River below Boca Dam near Truckee	172	5,500	1940	Present	39
uckee River at Farad	932	5,153.21	1900	Present	79
g Creek near Verdi	16.2	5,660	1957	1961	5
nter Creek near Reno	11.5	5,070	1962	1974	12*
avine Creek near Reno	2.34	4,990	1963	1974	12
uckee River at Reno	1,067	4,431.97	1907	Present	52*
anktown Creek near Carson City	3.24	7,380	1975	Present	4
shoe Lake near Carson City	83.8	--	1963	Present	16
ttle Washoe Lake near Steamboat	83.8	--	1963	Present	16
lena Creek near Steamboat	8.5	5,592	1962	Present	17
eamboat Creek at Steamboat	123	4,600	1962	Present	17
ites Creek near Steamboat	8.02	5,955	1962	1966	5
uckee River near Vista	1,429	4,368.59	1900	Present	50*
uckee River below Tracy	1,590	4,238.15	1973	Present	6
uckee River below Derby Dam	1,670	4,200	1909	Present	60*
uckee River at Wadsworth	1,719	4,037.90	1966	Present	13
uckee River near Nixon	1,815	3,940	1958	Present	21
uckee Canal near Wadsworth	--	4,200	1967	Present	12

:ord

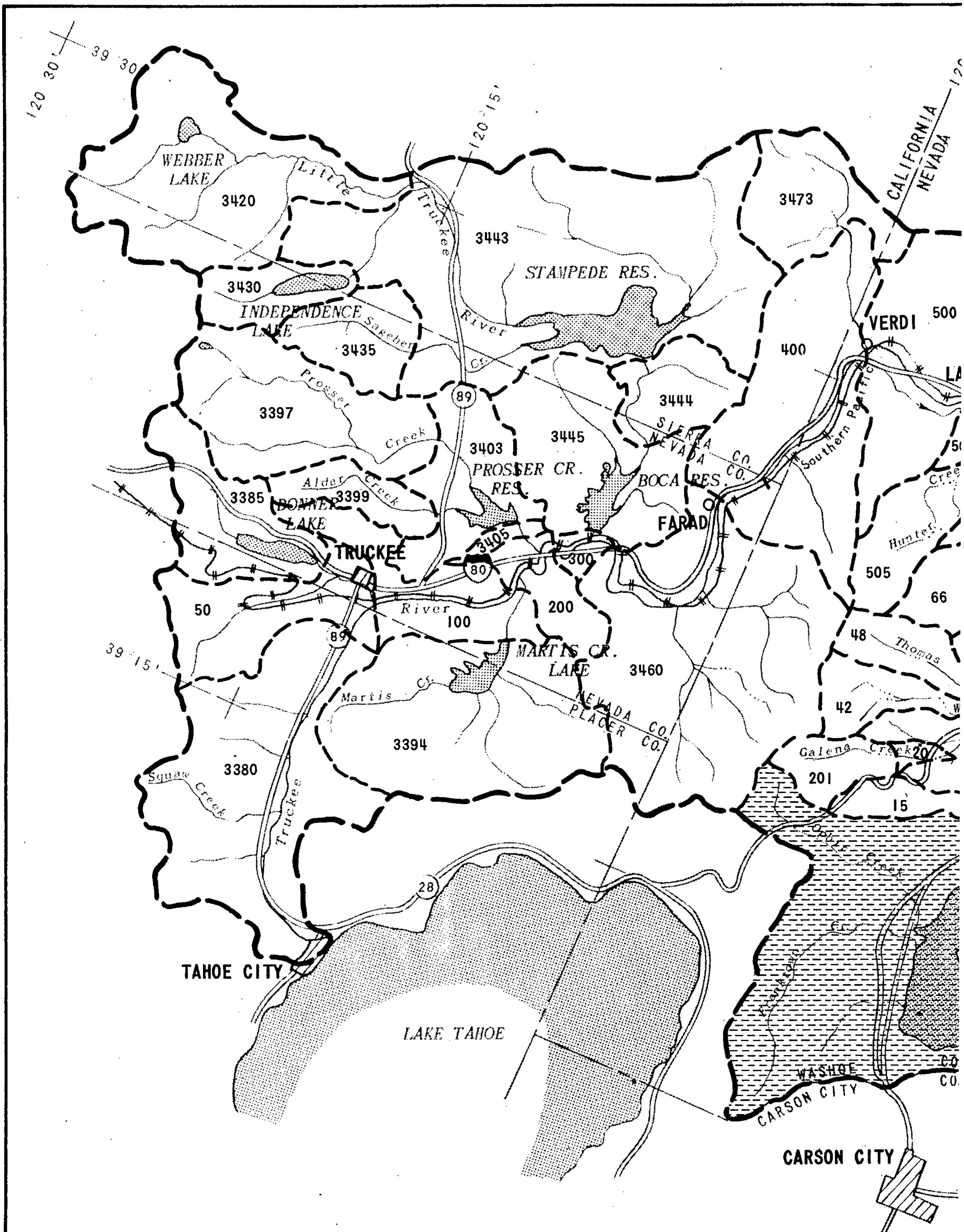
TRUCKEE RIVER, CALIFORNIA; NEVADA

STREAM GAGE
LOCATION MAP

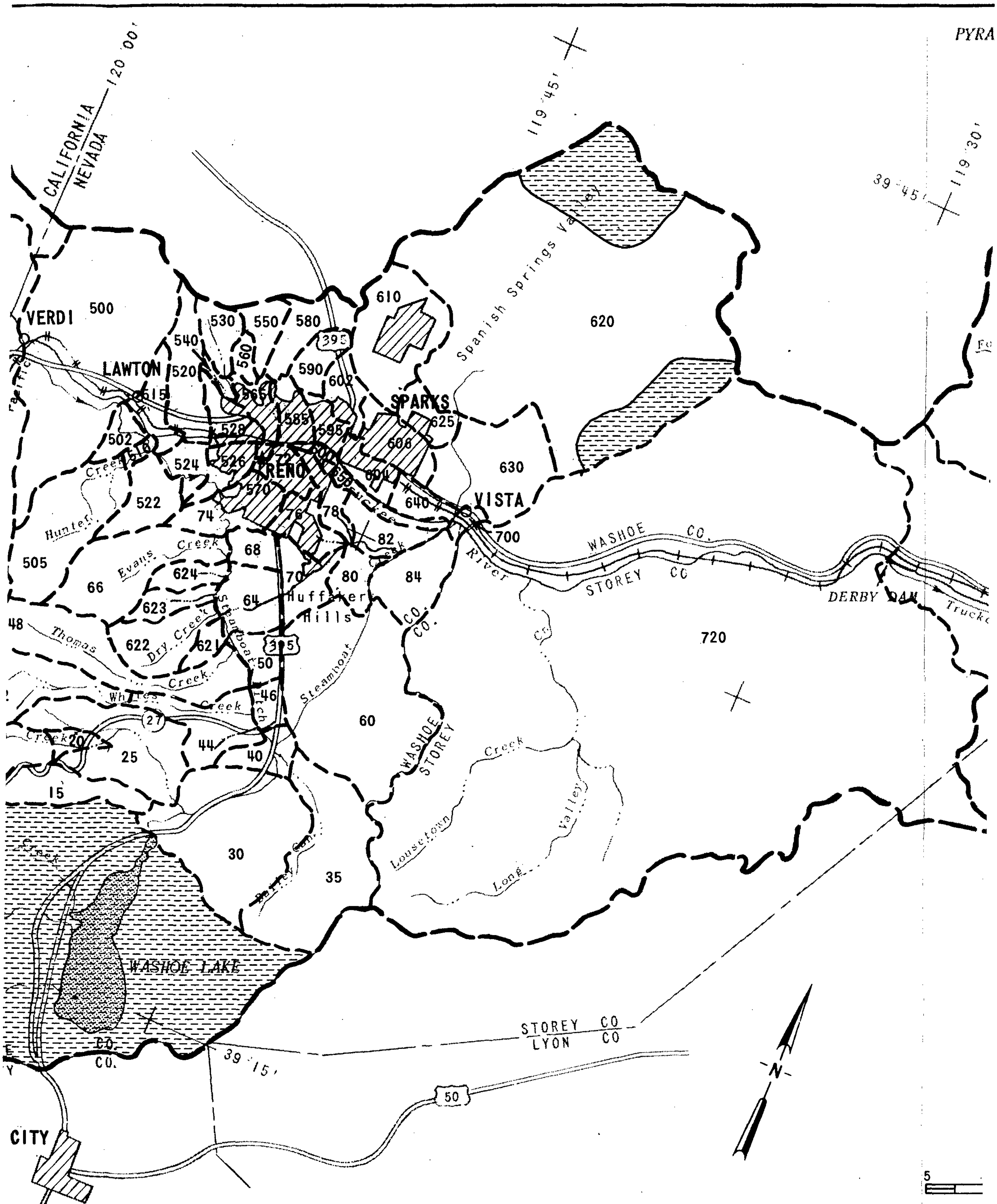
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: C.A.P.
Date: NOVEMBER 1979

CHART 6



120 30'
39 30'
120 15'
39 15'
CALIFORNIA
NEVADA
WEBBER LAKE
3420
Little
Truckee
3443
3473
STAMPEDE RES.
3430
INDEPENDENCE LAKE
Sagehen
River
3435
VERDI
500
400
Prosser
89
3444
3397
Creek
3403
3445
SIERRA CO.
NEVADA CO.
Southern Pacific
PROSSER CR. RES.
BOCA RES.
Alder
Creek
3385
3399
DONNER LAKE
FARAD
TRUCKEE
3405
80
300
Hunter
505
66
50
River
100
200
48
Thomas
89
MARTIS CR. LAKE
3460
Martis
Cr.
42
NEVADA CO.
PLACER CO.
3394
Galena
Creek
3380
201
Squaw
Creek
15
Truckee
28
TAHOE CITY
LAKE TAHOE
WASHOE
CARSON CITY
CARSON CITY


PYRA
120°00'
119°45'
119°30'
39°45'
39°15'
CALIFORNIA
NEVADA
VERDI
LAWTON
RENO
SPARKS
VISTA
DERBY DAM
Spanish Springs Valley
Huffaker Hills
WASHOE LAKE
WASHOE CO.
STOREY CO.
STOREY CO
LYON CO
WASHOE
STOREY
CITY
Truckee
River
Steamboat
Steamboat Ditch
Hunter Creek
Evans Creek
Thomas Creek
Dry Creek
Whites Creek
Lousetown
Long Valley
Creek
395
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625
630
640
700
720
15
20
25
30
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44
46
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64
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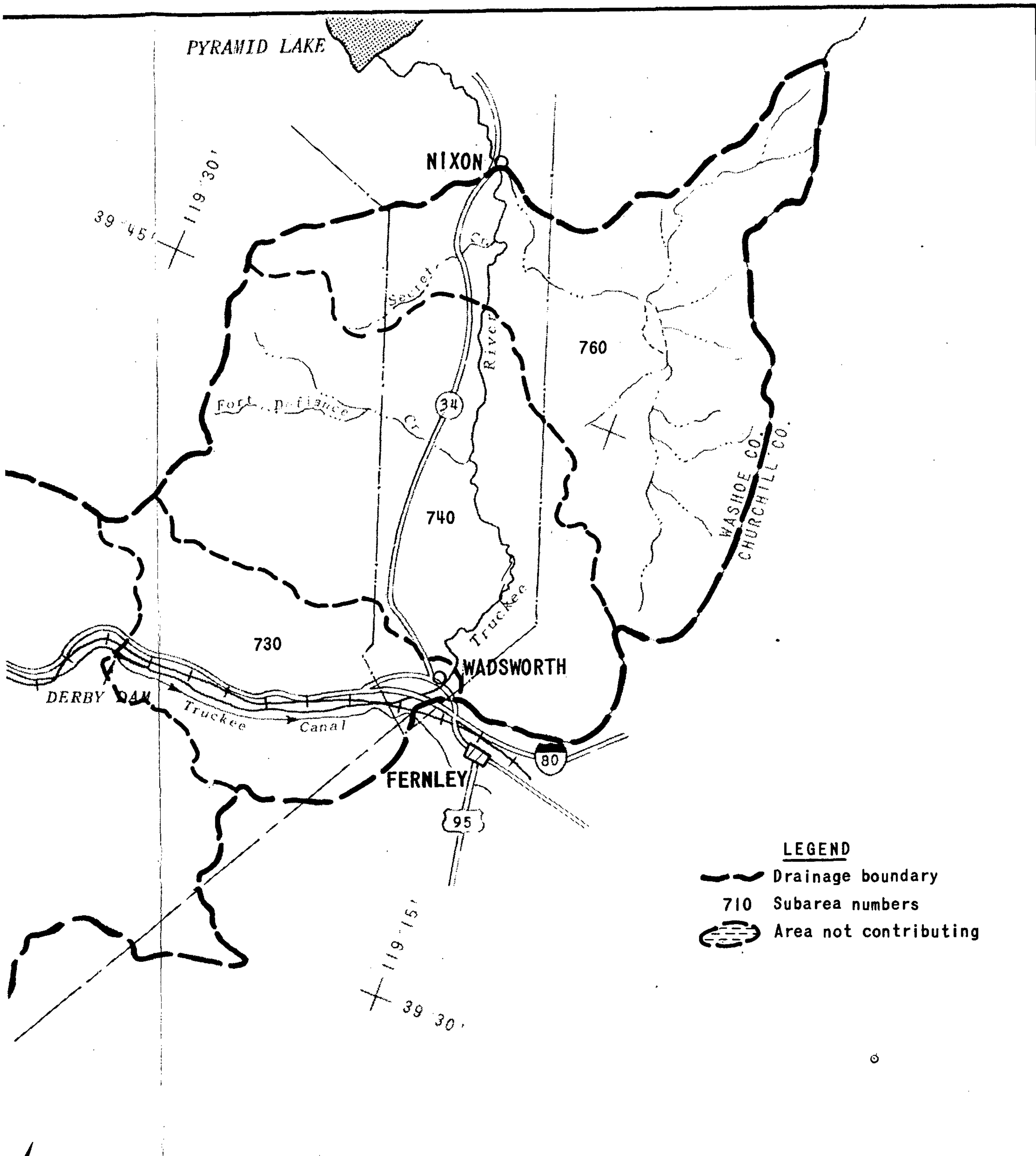
82
84
5



SCALE
5 0 5
(Miles)

TRUCKEE RIVER, CALIFORNIA; NEVADA

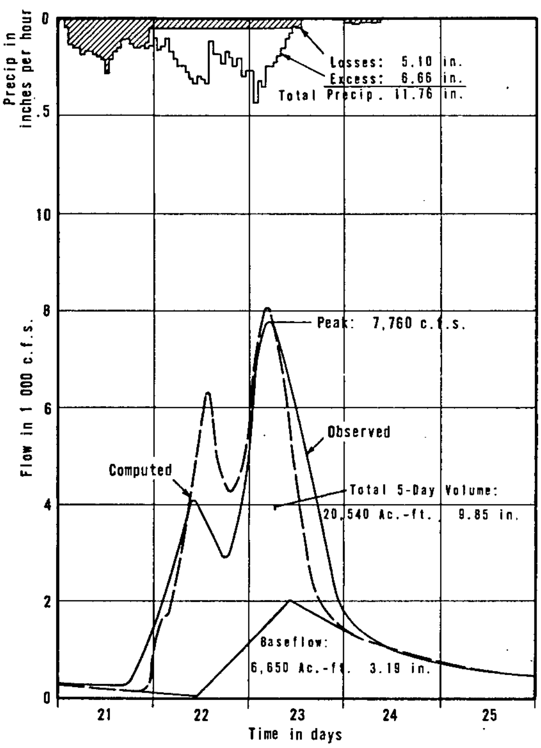
SUBAREA MAP

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

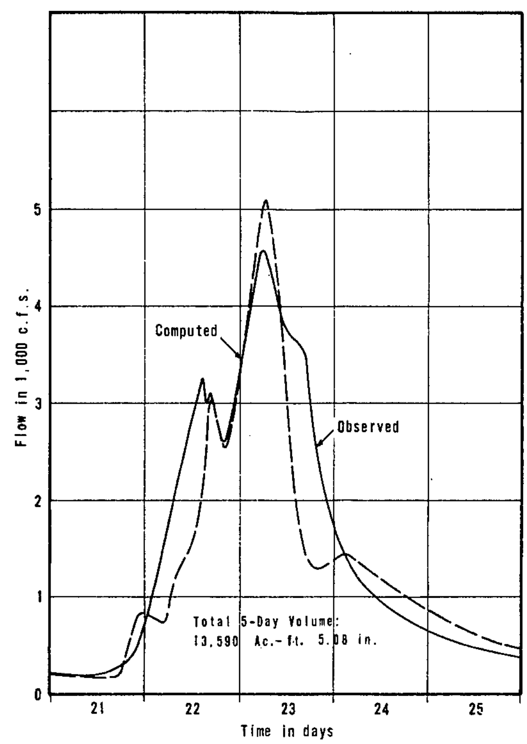
Prepared: P.W.
Drawn: C.A.P.

Date NOVEMBER 1979

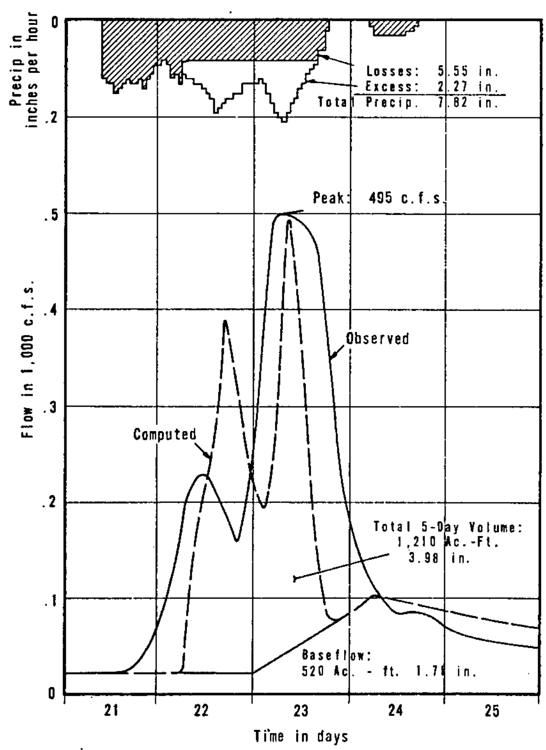
CHART 7



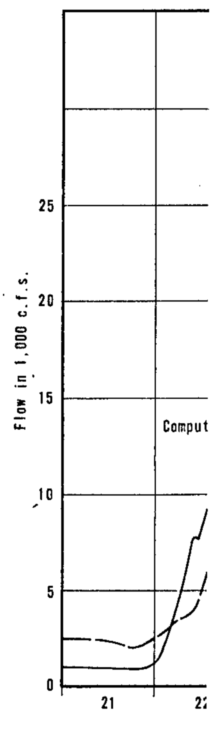
TRUCKEE RIVER NEAR TRUCKEE, CALIFORNIA
U.S.G.S. - 3380
Contributing drainage area: 39.1 sq. mi.



PROSSER CREEK NEAR BOCA, CALIFORNIA
U.S.G.S. - 3405
Contributing drainage area: 50.2 sq. mi.

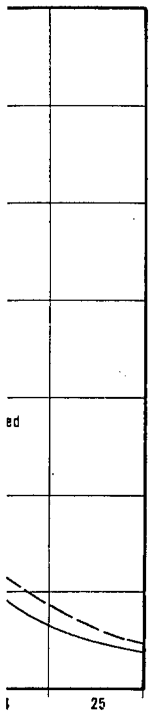


SAGEHEN CREEK NEAR TRUCKEE, CALIFORNIA
U.S.G.S. - 3435
Contributing drainage area: 5.7 sq. mi.

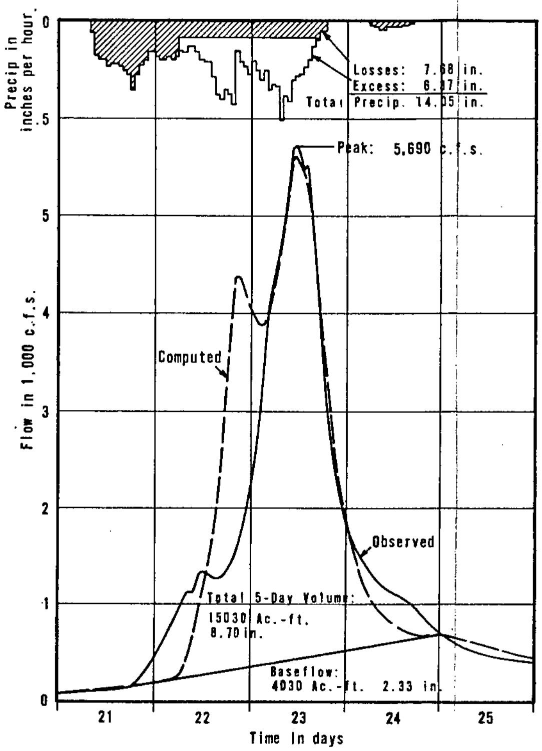


TRUCK

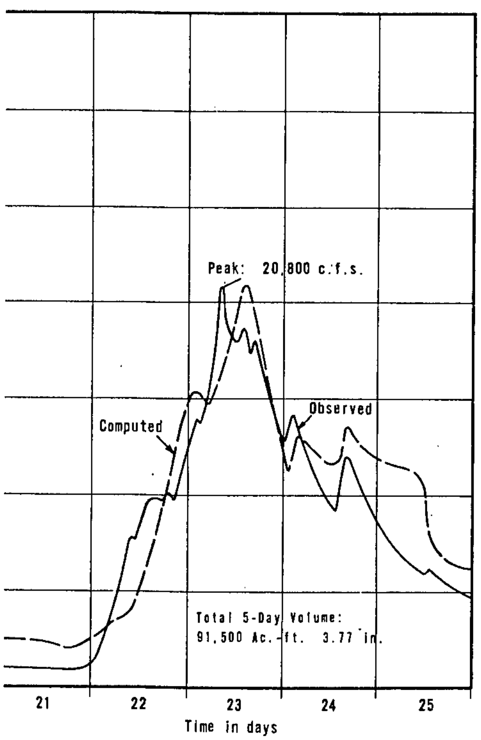
Contribut



.IFORNIA
sq. mi.



LITTLE TRUCKEE RIVER NEAR HOBART MILLS, CALIFORNIA
U.S.G.S. - 3420
Contributing drainage area: 32.4 sq. mi.



TRUCKEE RIVER AT RENO, NEVADA
Index Point-600 -
Contributing drainage area: 455.0 sq. mi.

NOTE: All precipitation shown is based on a rain on snow analysis.

TRUCKEE RIVER, CALIFORNIA;NEVADA

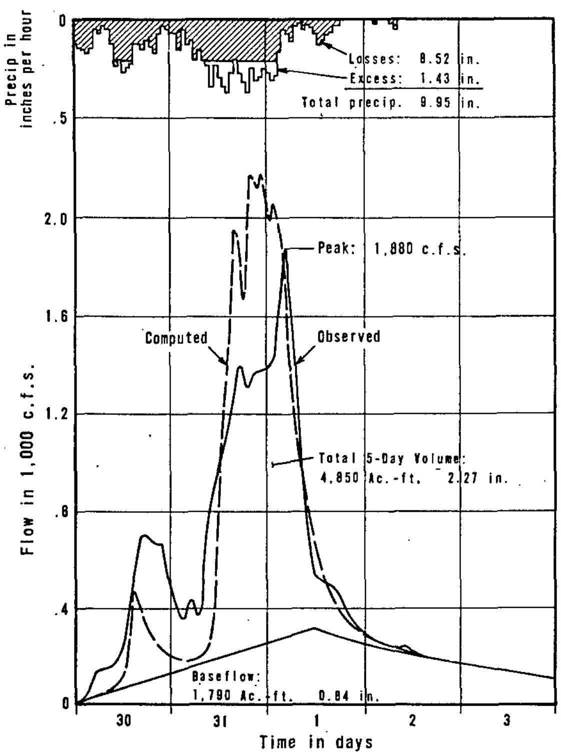
DECEMBER 1955
FLOOD HYDROGRAPHS

CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA

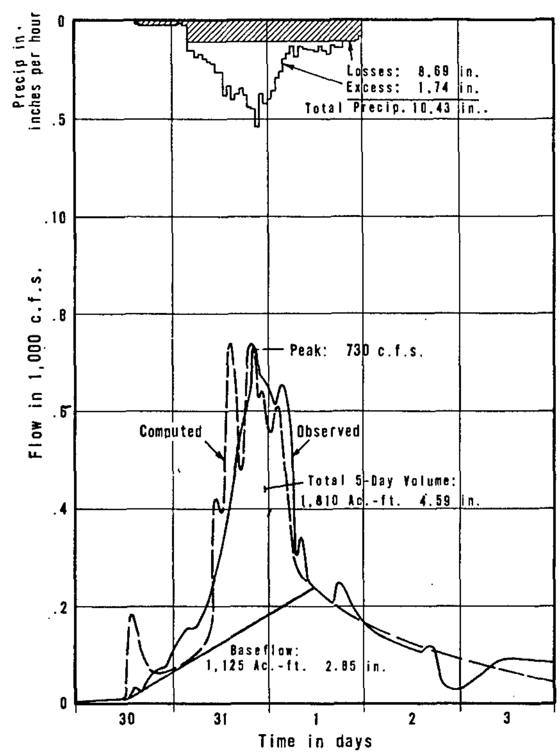
Prepared: P.W.,C.A.P.
Drawn: C.A.P.

Date: NOVEMBER 1979

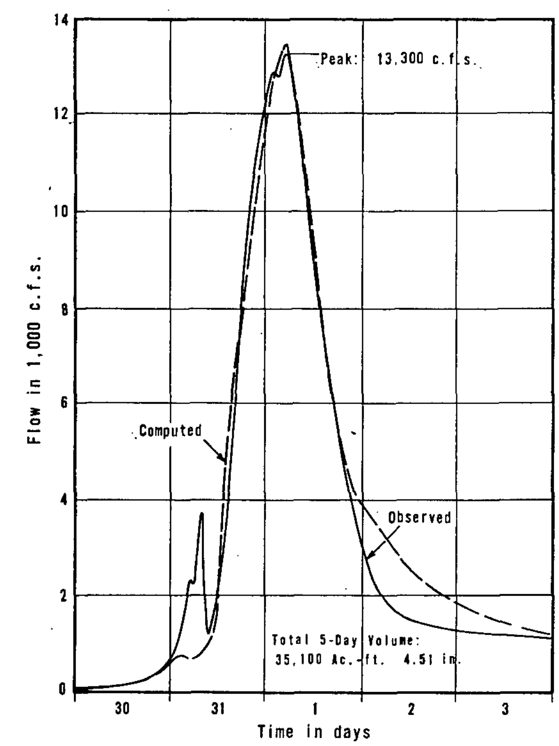
CHART 8



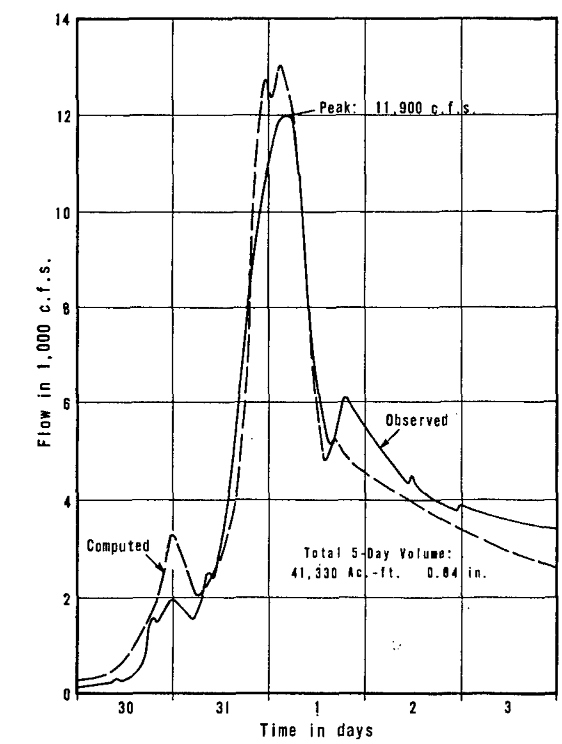
MARTIS CREEK AT TRUCKEE, CALIFORNIA
U.S.G.S. - 3394
Drainage area - 40.0 sq.mi.



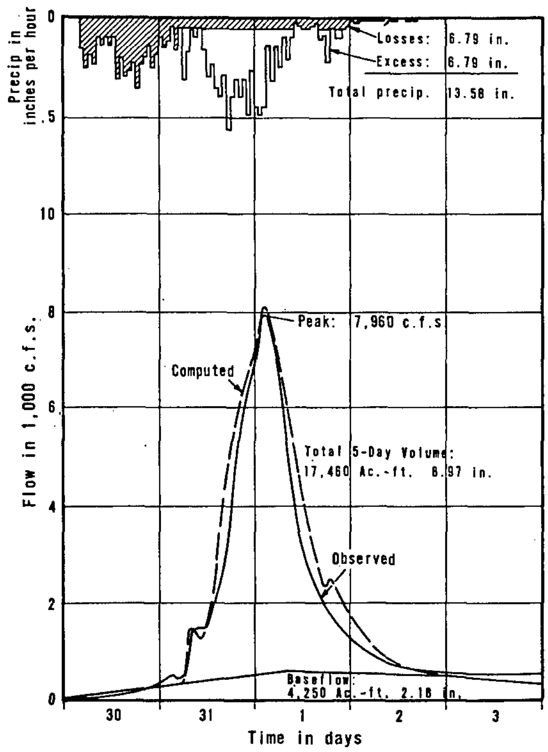
ALDER CREEK NEAR TRUCKEE, CALIFORNIA
U.S.G.S. - 3399
Drainage area: 7.4 sq.mi.



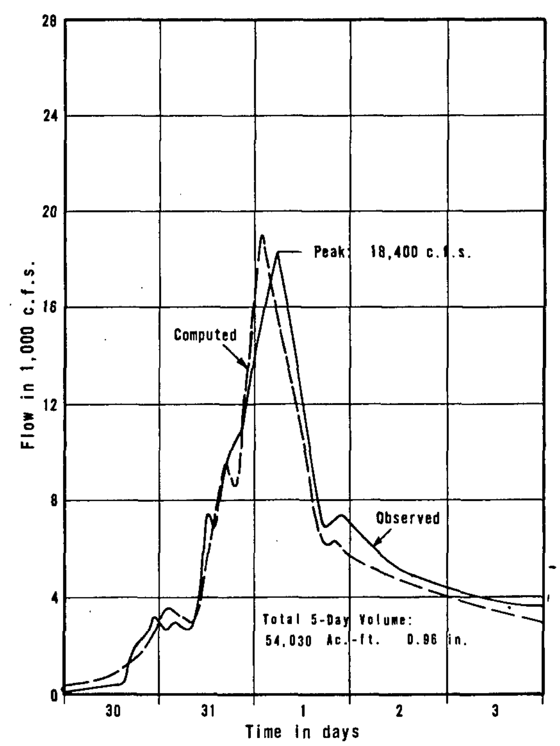
LITTLE TRUCKEE RIVER ABOVE BOCA RESERVOIR
NEAR BOCA, CALIFORNIA
U.S.G.S. - 3444
Drainage area 146.0 sq.mi.



TRUCKEE RIVER AT FARAD, CALIFORNIA
U.S.G.S. - 3460
Drainage area 923.0 sq.mi.



LITTLE TRUCKEE RIVER NEAR HOBART MILLS, CALIFORNIA
U.S.G.S. - 3420
Drainage area 36.5 sq.mi.



TRUCKEE RIVER AT RENO, NEVADA
Index point 600
Contributing drainage area: 1,049.3 sq.mi.

TRUCKEE RIVER, CALIFORNIA;NEVADA

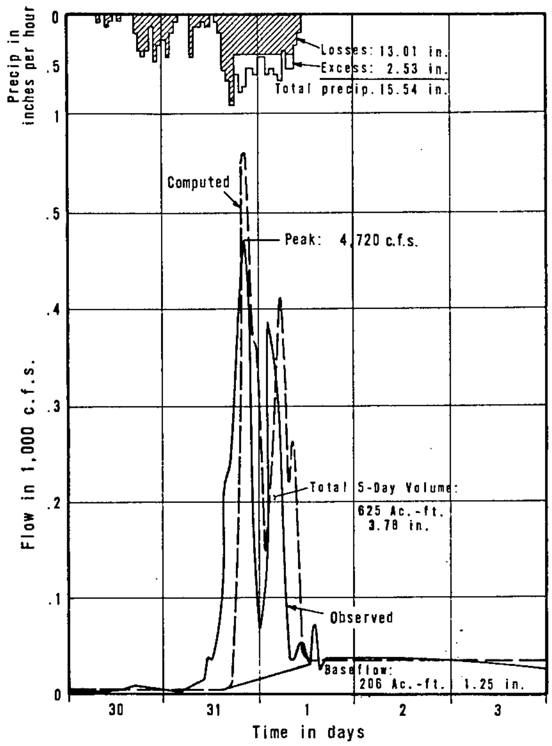
JANUARY-FEBRUARY 1963
FLOOD HYDROGRAPHS

CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA

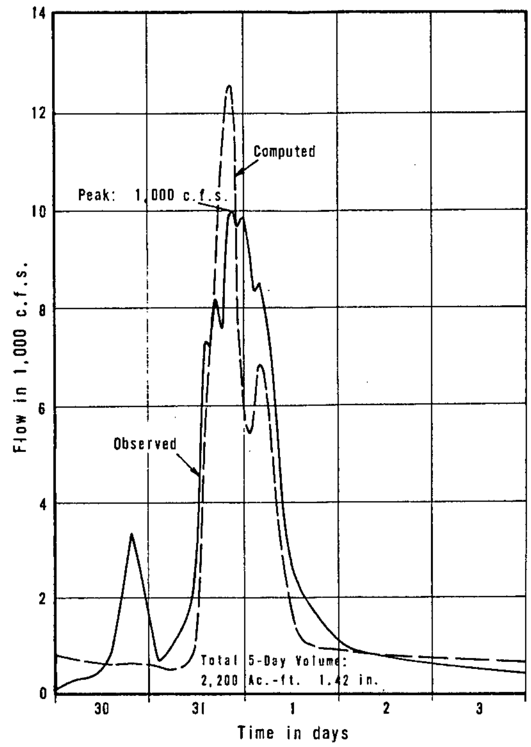
Prepared: P.W., C.A.P.
Drawn: C.A.P.
Date: NOVEMBER 1979

SHEET 1 OF 2 CHART 9

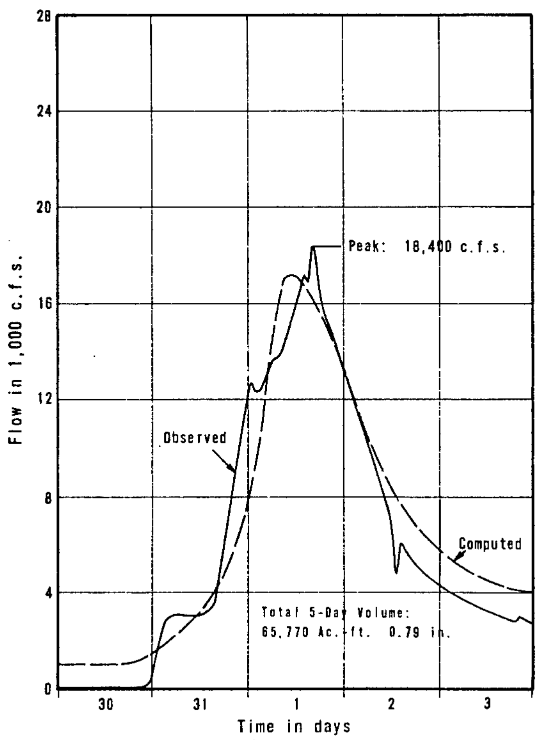
2



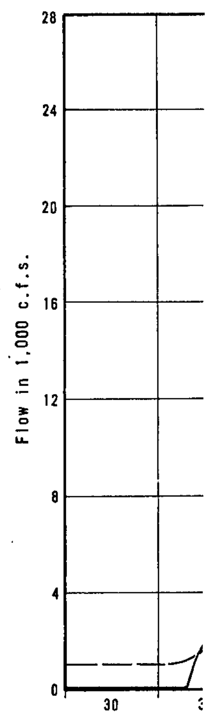
GALENA CREEK NEAR STEAMBOAT, NEVADA
Index point 20
Contributing drainage area: 3.1 sq.mi.



STEAMBOAT CREEK AT STEAMBOAT, NEVADA
Index point 30
Contributing drainage area: 32.4 sq.mi.

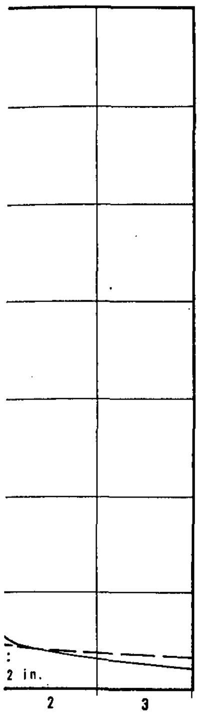


TRUCKEE RIVER BELOW DERBY DAM, NEAR WADSWORTH, NEVADA
Index point 720
Contributing drainage area: 1,532.2 sq.mi.



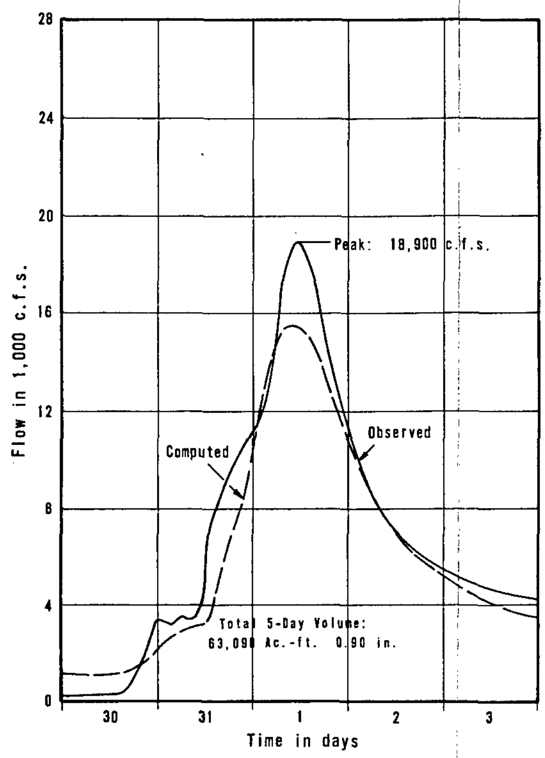
TRUCKE

Contribu

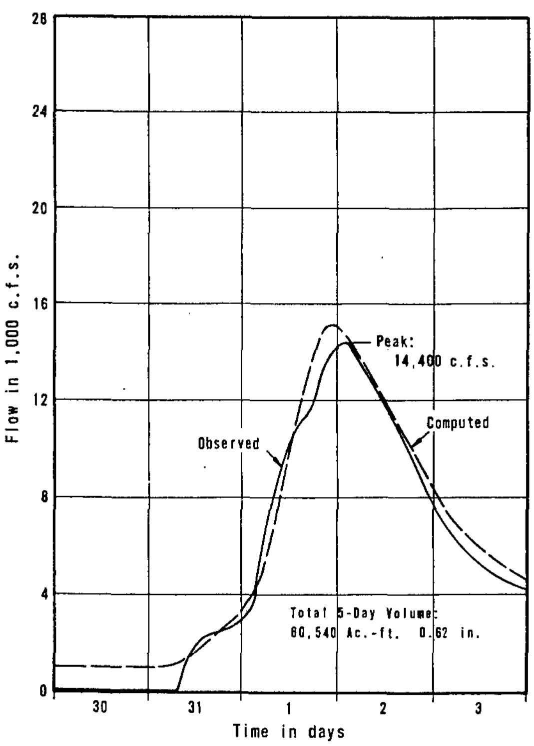


s

MBOAT, NEVADA
10
: 32.4 sq.mi.



TRUCKEE RIVER AT VISTA, NEVADA
Index point 700
Contributing drainage area: 1,291.2 sq. mi.



TRUCKEE RIVER NEAR NIXON, NEVADA
Index point 740
Contributing drainage area: 1,677.2 sq.mi.

TRUCKEE RIVER, CALIFORNIA;NEVADA

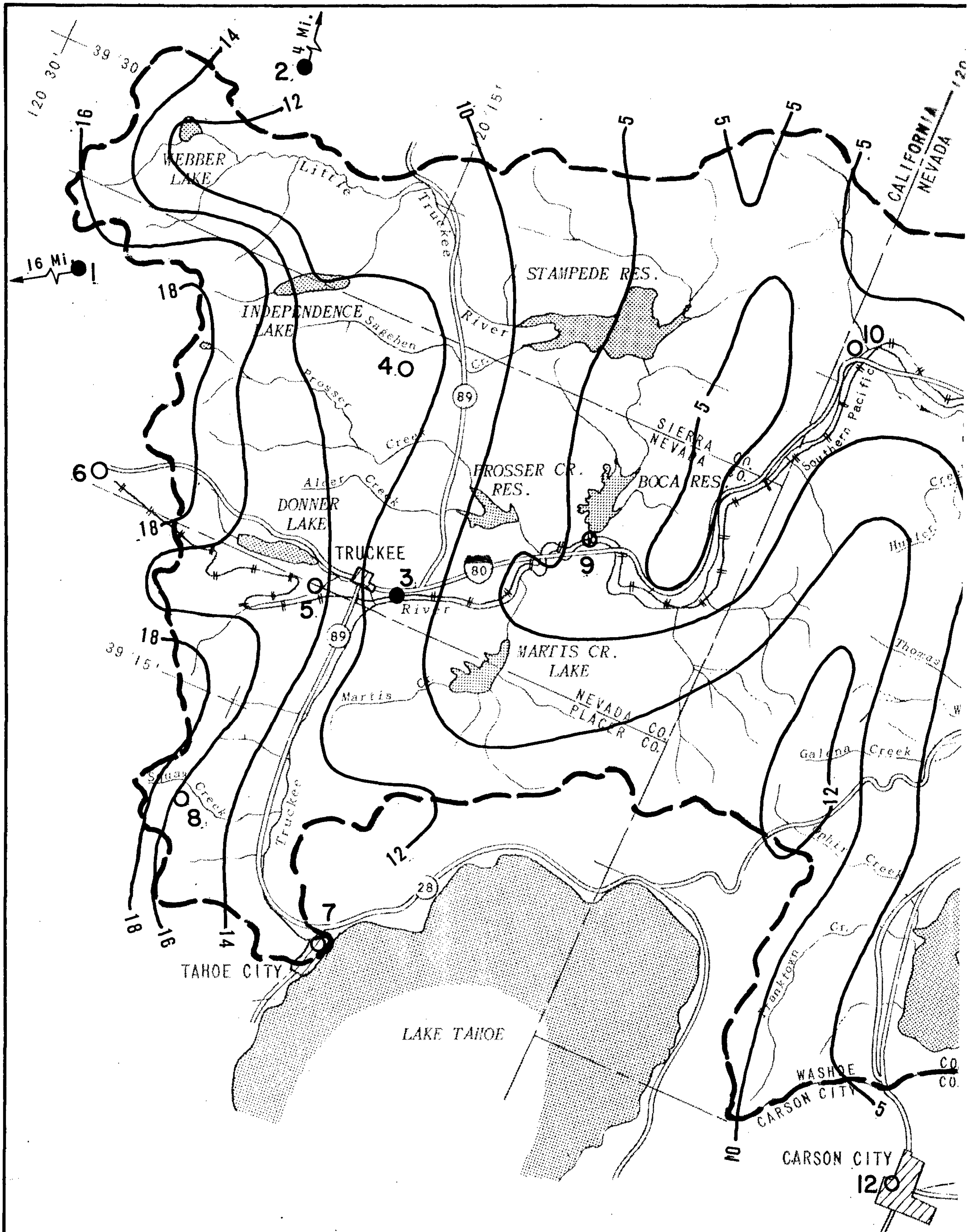
JANUARY-FEBRUARY 1963
FLOOD HYDROGRAPHS

CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA

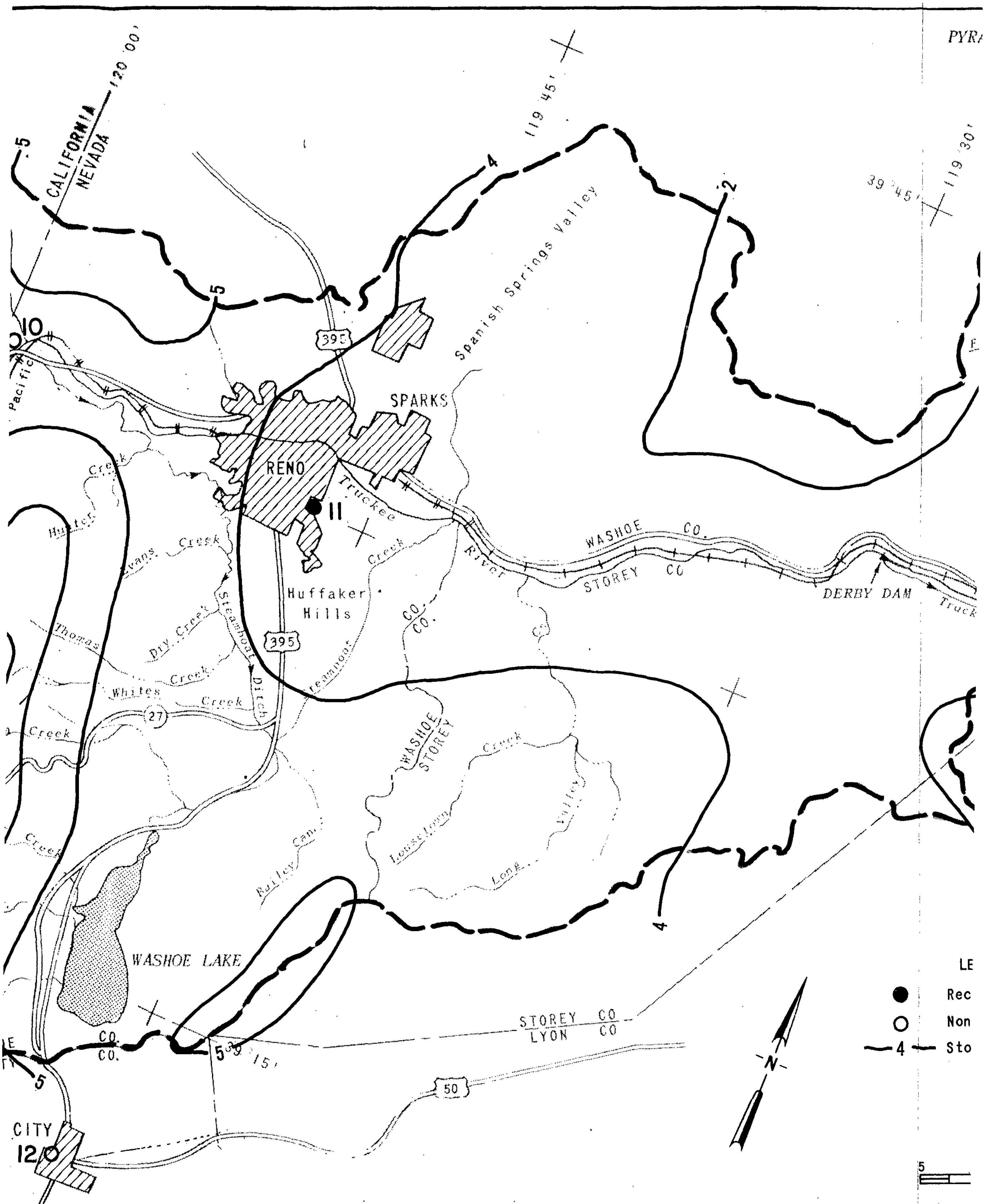
Prepared: P.W.,C.A.P.
Drawn: C.A.P.

Date: NOVEMBER 1979

SHEET 2 OF 2 CHART 9



39°30'
120°30'
120°15'
39°15'
4 Mi.
16 Mi.
WEBBER LAKE
Little Truckee
INDEPENDENCE LAKE
Sagehen Cr.
Prosser Creek
STAMPEDE RES.
River
PROSSER CR. RES.
BOCA RES.
SIERRA CO.
NEVADA CO.
Alder Creek
DONNER LAKE
TRUCKEE
River
MARTIS CR. LAKE
Martis Cr.
NEVADA CO.
PLACER CO.
Squaw Creek
Truckee
TAHOE CITY
LAKE TAHOE
Southern Pacific
CALIFORNIA
NEVADA
Hunter
Thomas
Galena Creek
Ophir Creek
Franktown Cr.
WASHOE CO.
CARSON CITY CO.
CARSON CITY
89
80
28



CALIFORNIA
NEVADA
120°00'
119°45'
119°30'
39°45'
PYR
Pacific
SPARKS
RENO
Spanish Springs Valley
Truckee River
WASHOE CO.
STOREY CO
DERBY DAM
Huffaker Hills
395
27
50
Steamboat Ditch
Hunter Creek
Evans Creek
Thomas Creek
Dry Creek
Whites Creek
Steamboat Creek
WASHOE STOREY
Lousetown Creek
Long Valley
Bailey Can.
WASHOE LAKE
STOREY CO
LYON CO
CITY
10
11
12
LE
Rec
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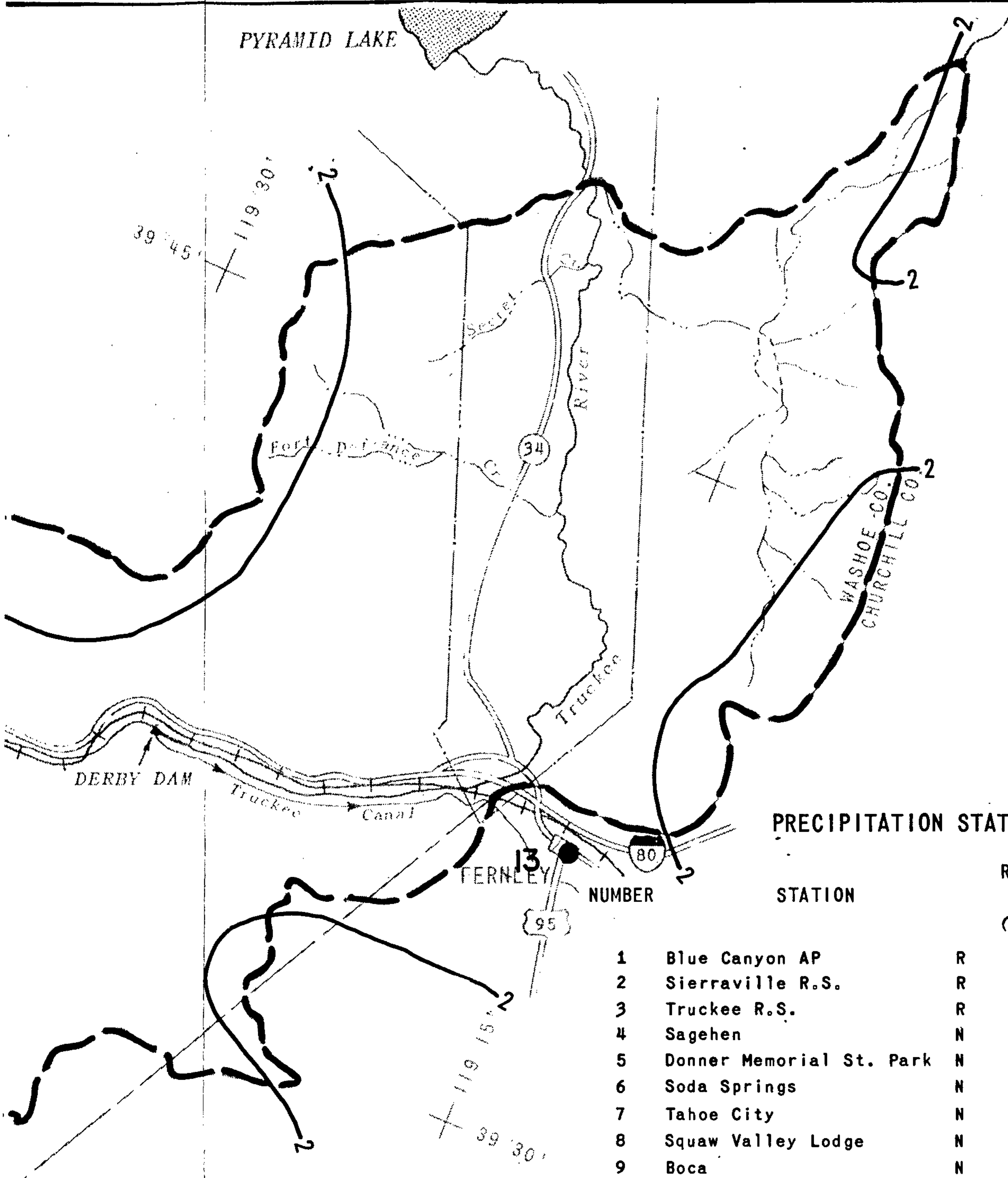
Sto
N



PRECIPITATION STATIONS

NUMBER	STATION		RAINFALL AMOUNT *(Inches)*	YEARS OF RECORD
1	Blue Canyon AP	R	19.20	39
2	Sierraville R.S.	R	10.06	96
3	Truckee R.S.	R	11.76	96
4	Sagehen	N	12.70	25
5	Donner Memorial St. Park	N	15.50	25
6	Soda Springs	N	18.50	19
7	Tahoe City	N	12.08	69
8	Squaw Valley Lodge	N	14.30	19
9	Boca	N	6.80	89
10	Verdi	N	4.25	5
11	Reno NWS-AP	R	3.77	109
12	Carson City	N	7.80	82
13	Fernley	R	1.79	20

R = RECORDER; N = NON-RECORDER

LEGEND:

- ● Recorder
- ○ Non-Recorder
- —4— Storm Isohyet Amount in Inches

N

SCALE

5 0 5

(Miles)

TRUCKEE RIVER, CALIFORNIA; NEVADA

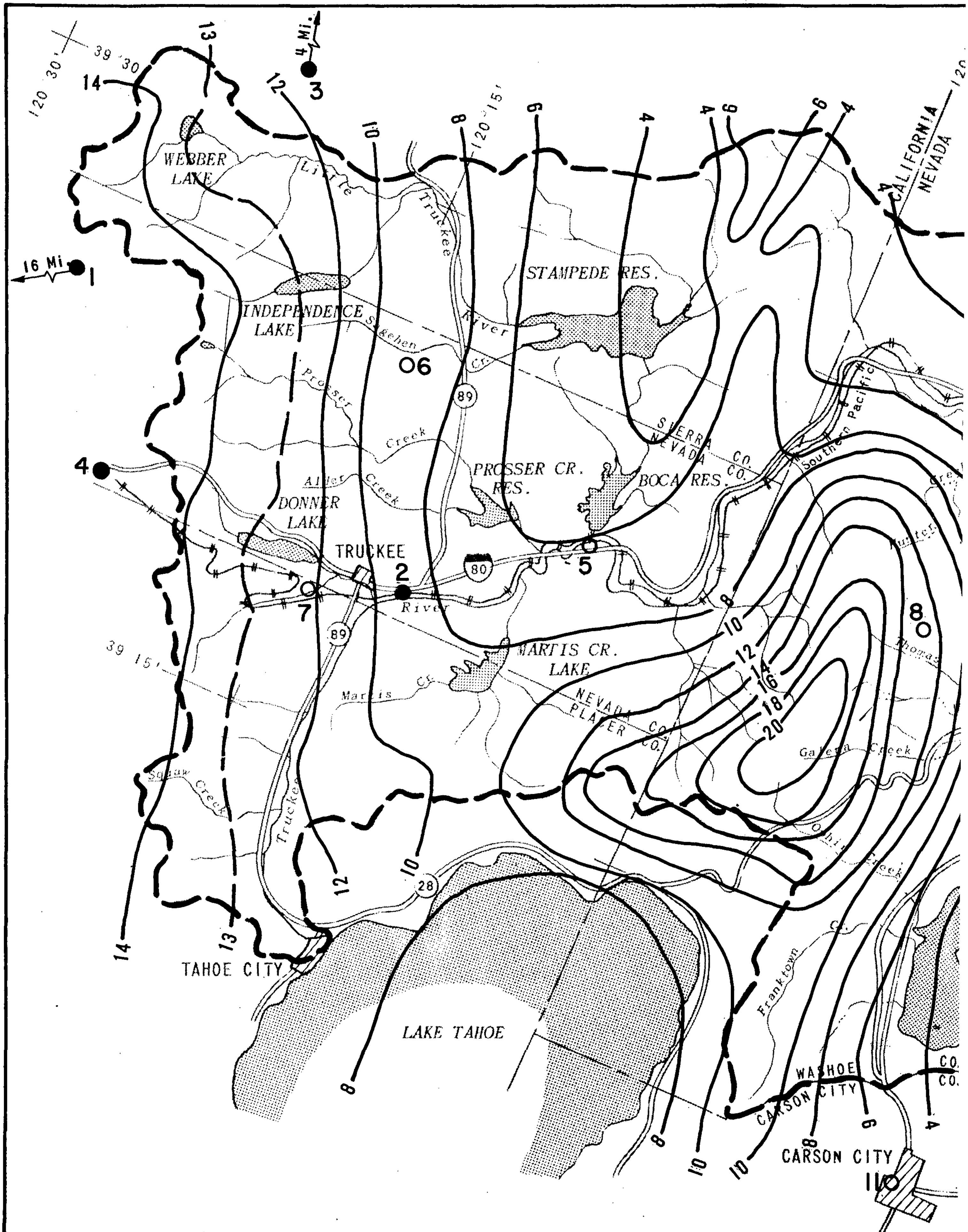
ISOHYETAL MAP
21-25 DECEMBER 1955

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

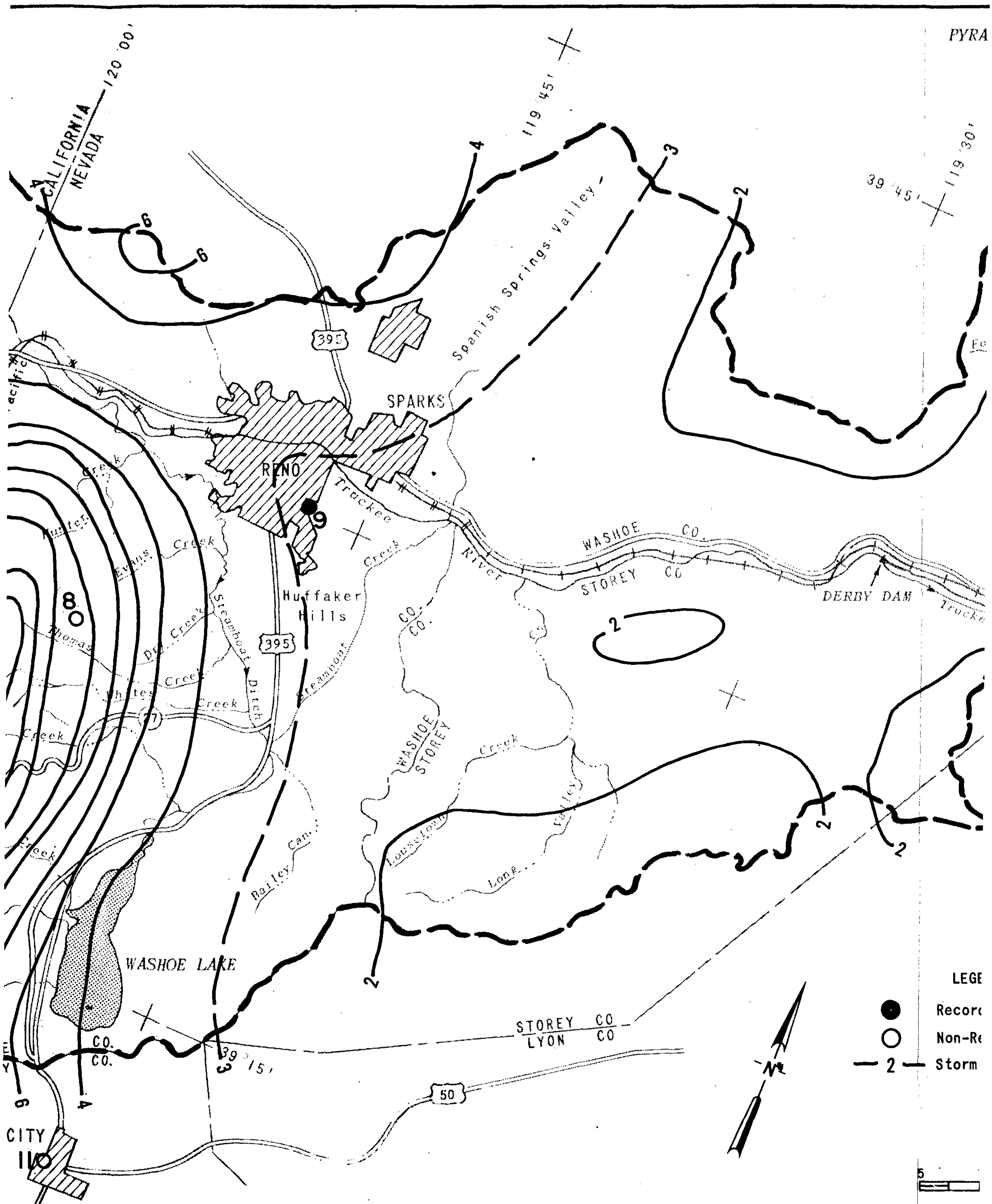
Prepared: P.W.
Drawn: C.A.P.

Date NOVEMBER 1979

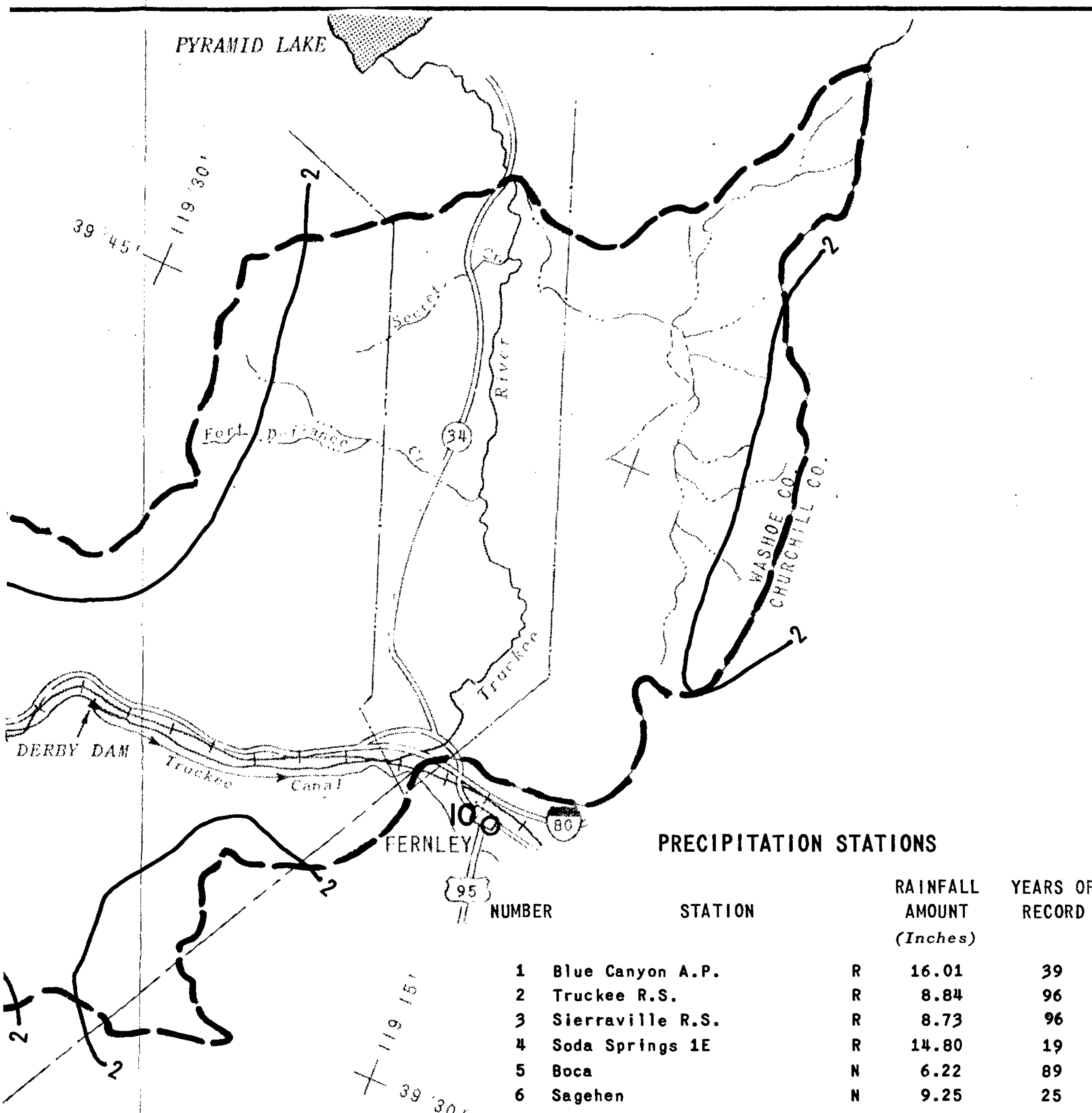
CHART 10



WEBBER LAKE
INDEPENDENCE LAKE
STAMPEDE RES.
PROSSER CR. RES.
BOCA RES.
DONNER LAKE
TRUCKEE
MARTIS CR. LAKE
LAKE TAHOE
TAHOE CITY
CARSON CITY
CALIFORNIA
NEVADA
SIERRA CO.
NEVADA CO.
NEVADA CO.
PLACER CO.
WASHOE CO.
CARSON CITY
Little Truckee River
Sagehen Cr.
Prosser Creek
Alder Creek
Truckee River
Martis Cr.
Squaw Creek
Galena Creek
Franktown Cr.
Southern Pacific
16 Mi.
4 Mi.
120°30'
39°30'
120°15'
39°15'
80
89
28


PYRA
CALIFORNIA
NEVADA
120°00'
119°45'
119°30'
39°45'
39°15'
Spanish Springs Valley
SPARKS
RENO
Huffaker Hills
Truckee River
WASHOE CO.
STOREY CO.
DERBY DAM
Hunter Creek
Evans Creek
Thomas Creek
Dry Creek
Whites Creek
Steamboat Ditch
Steamboat Creek
Bailey Can.
Long Valley Creek
WASHOE LAKE
STOREY CO
LYON CO
CITY
395
50
LEGE
Recor
Non-Re
— 2 — Storm

2



PRECIPITATION STATIONS

NUMBER	STATION		RAINFALL AMOUNT *(Inches)*	YEARS OF RECORD
1	Blue Canyon A.P.	R	16.01	39
2	Truckee R.S.	R	8.84	96
3	Sierraville R.S.	R	8.73	96
4	Soda Springs 1E	R	14.80	19
5	Boca	N	6.22	89
6	Sagehen	N	9.25	25
7	Donner Memorial St. Park	N	12.05	25
8	Mt. Rose Highway Station	N	13.58	4
9	Reno NWS-AP	R	2.59	109
10	Fernley	N	1.81	20
11	Carson City	N	7.14	82

R = RECORDER; N = NON-RECORDER

LEGEND:

● Recorder

○ Non-Recorder

— 2 — Storm Isohyet Amount in Inches

SCALE

5 0 5

(Miles)

TRUCKEE RIVER, CALIFORNIA; NEVADA

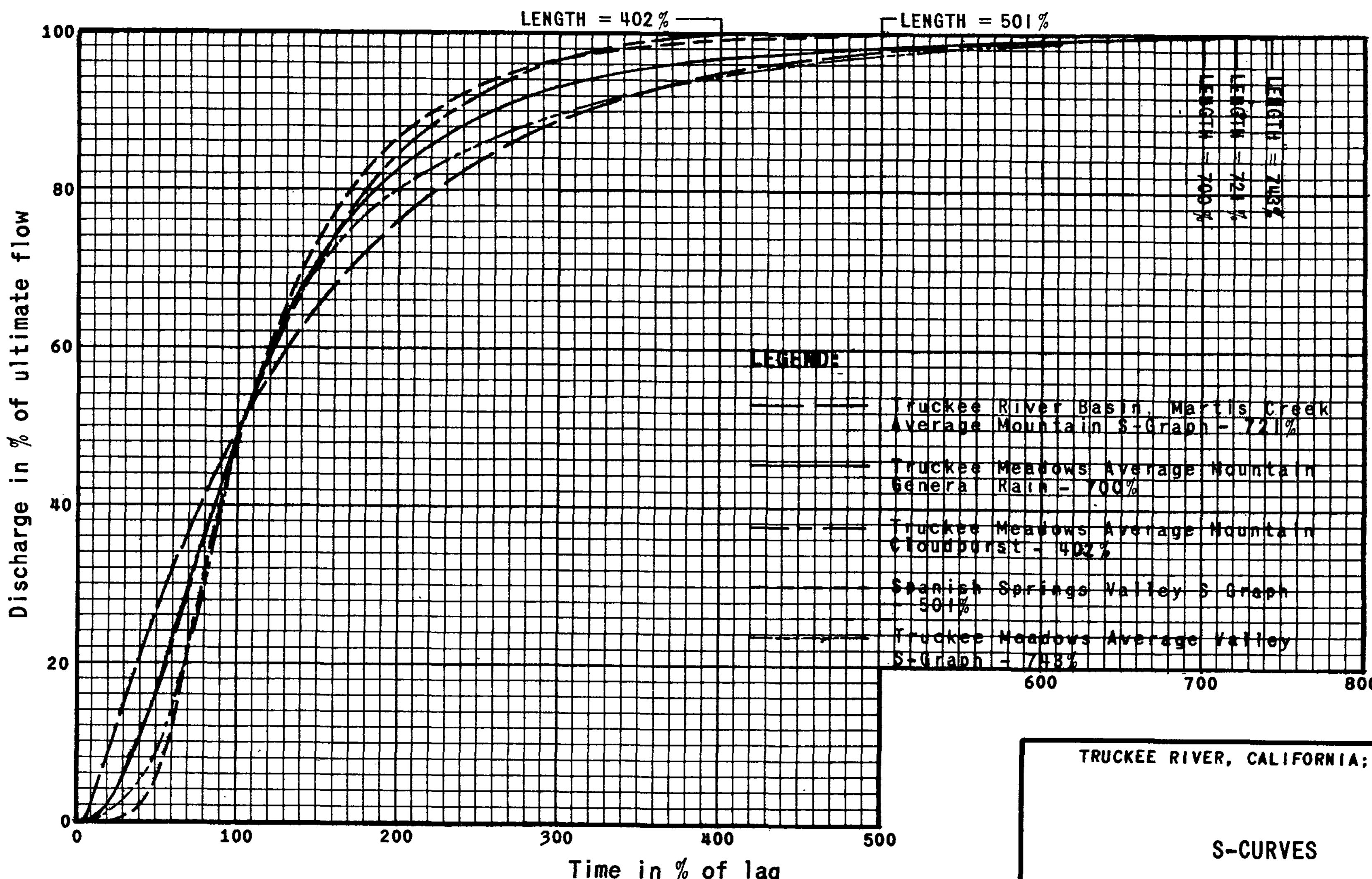
ISOHYETAL MAP
30 JAN - 1 FEB 1963

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: C.A.P.

Date NOVEMBER 1979

CHART 11



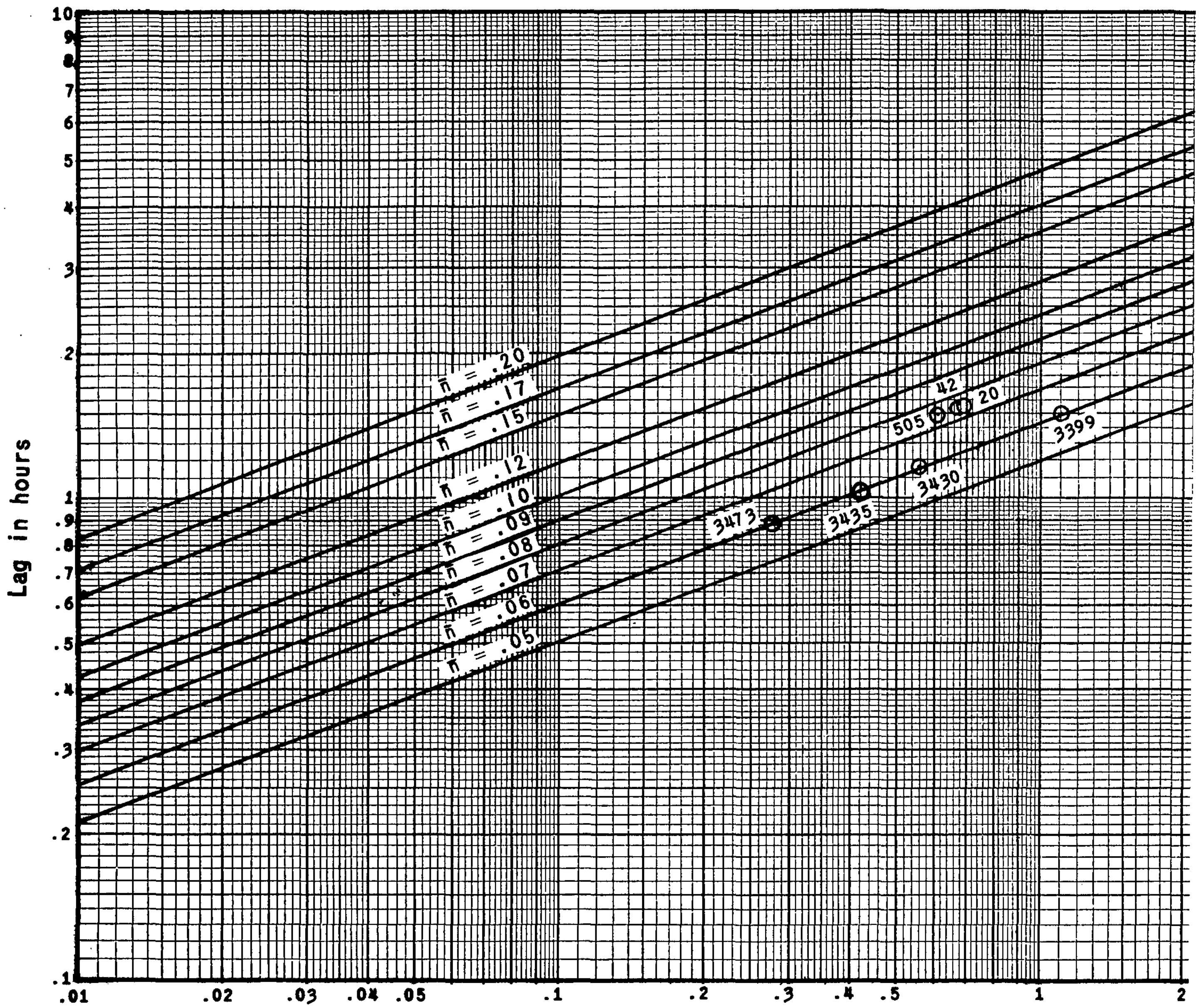
TRUCKEE RIVER, CALIFORNIA; NEVADA

S-CURVES

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: C.A.P.
Date: NOVEMBER 1979

CHART 12



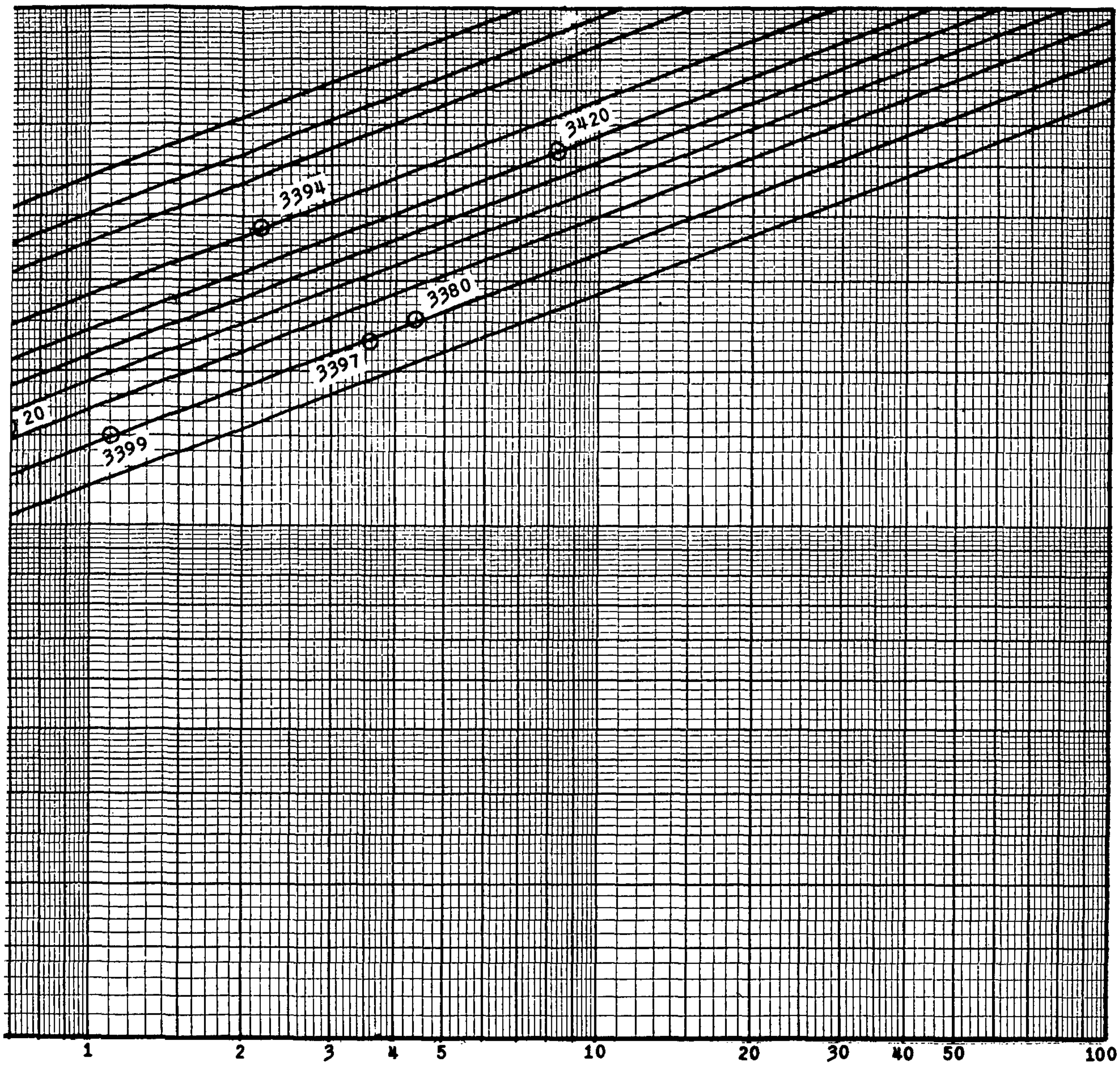
$$\frac{LL_{ca}}{S^{0.5}}$$

TERMINOLO

L - Length of longest watercourse.

L_{ca} - Length along longest watercourse, measured upstream to point opposite center of area.

S - Overall slope of longest watercourse between headwater and collection point.



$$\frac{LL_{ca}}{S^{0.5}}$$

U

SUBAREAS

20	Galena
42	Whites
505	Hunter
3380	Truckee
3394	Martis
3397	Prosser
3399	Alder C
3420	Little
3430	Indepen
3435	Sagehen
3473	Dog Cre

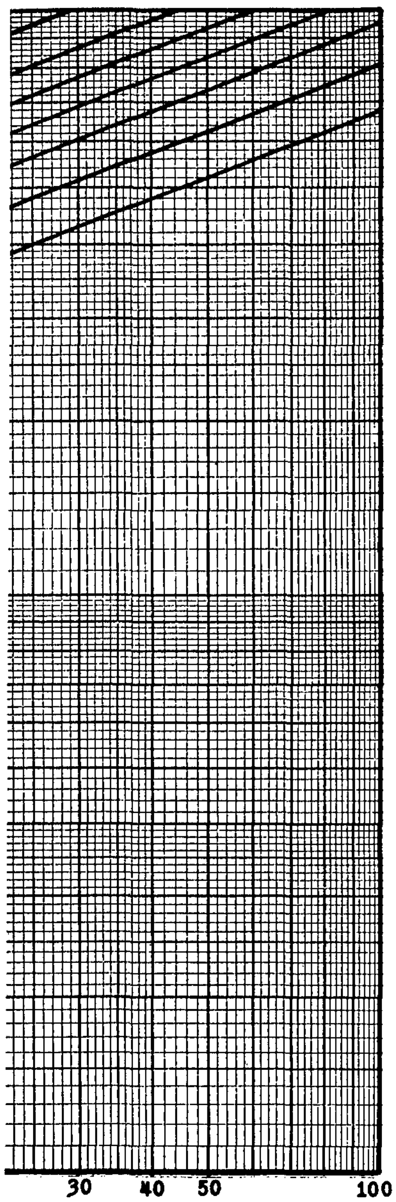
TERMINOLOGY

tercourse.
watercourse,
point
rea.

jest water-
ater and

Lag - Elapsed time from beginning of unit precipitation to instant that summation hydrograph reaches 50% of ultimate discharge.

$\bar{n}$ - Basin factor representing basin shape, drainage pattern, and roughness of the stream beds.



USGS GAGING STATIONS

SUBAREAS	LOCATION
20	Galena Creek near Steamboat, Nev. - USGS-3489
42	Whites Creek near Steamboat, Nev. - USGS-3497
505	Hunter Creek near Reno, Nev. - USGS-3476
3380	Truckee River near Truckee, Cal.
3394	Martis Creek near Truckee, Cal.
3397	Prosser Creek near Hobart Mills, Cal.
3399	Alder Creek near Truckee, Cal.
3420	Little Truckee River near Hobart Mills, Cal.
3430	Independence Creek near Truckee, Cal.
3435	Sagehen Creek near Truckee, Cal.
3473	Dog Creek near Verdi, Nev.

f

in

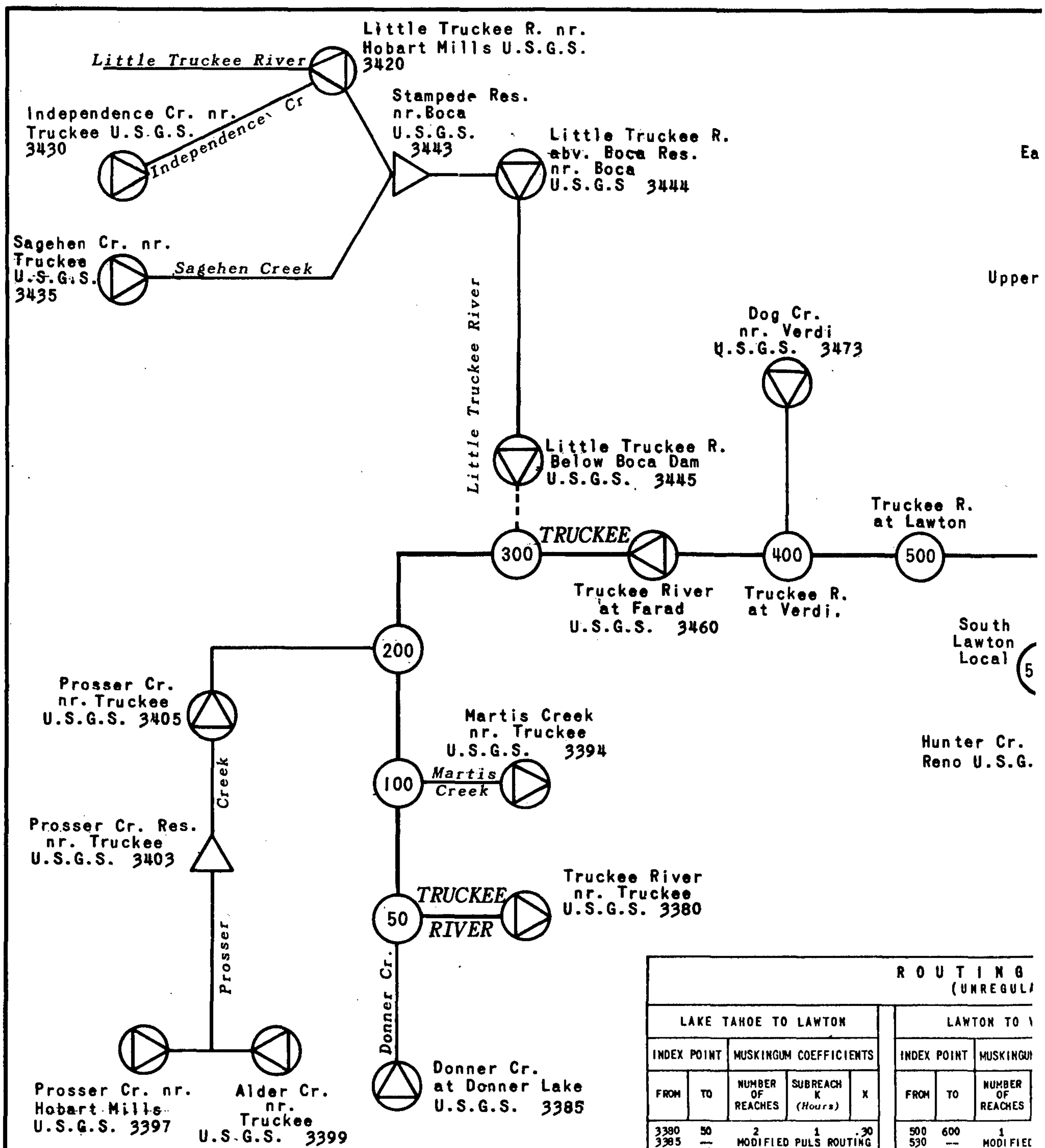
TRUCKEE RIVER, CALIFORNIA; NEVADA

LAG RELATIONSHIPS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: C.A.P.
Date: NOVEMBER 1979

CHART 13



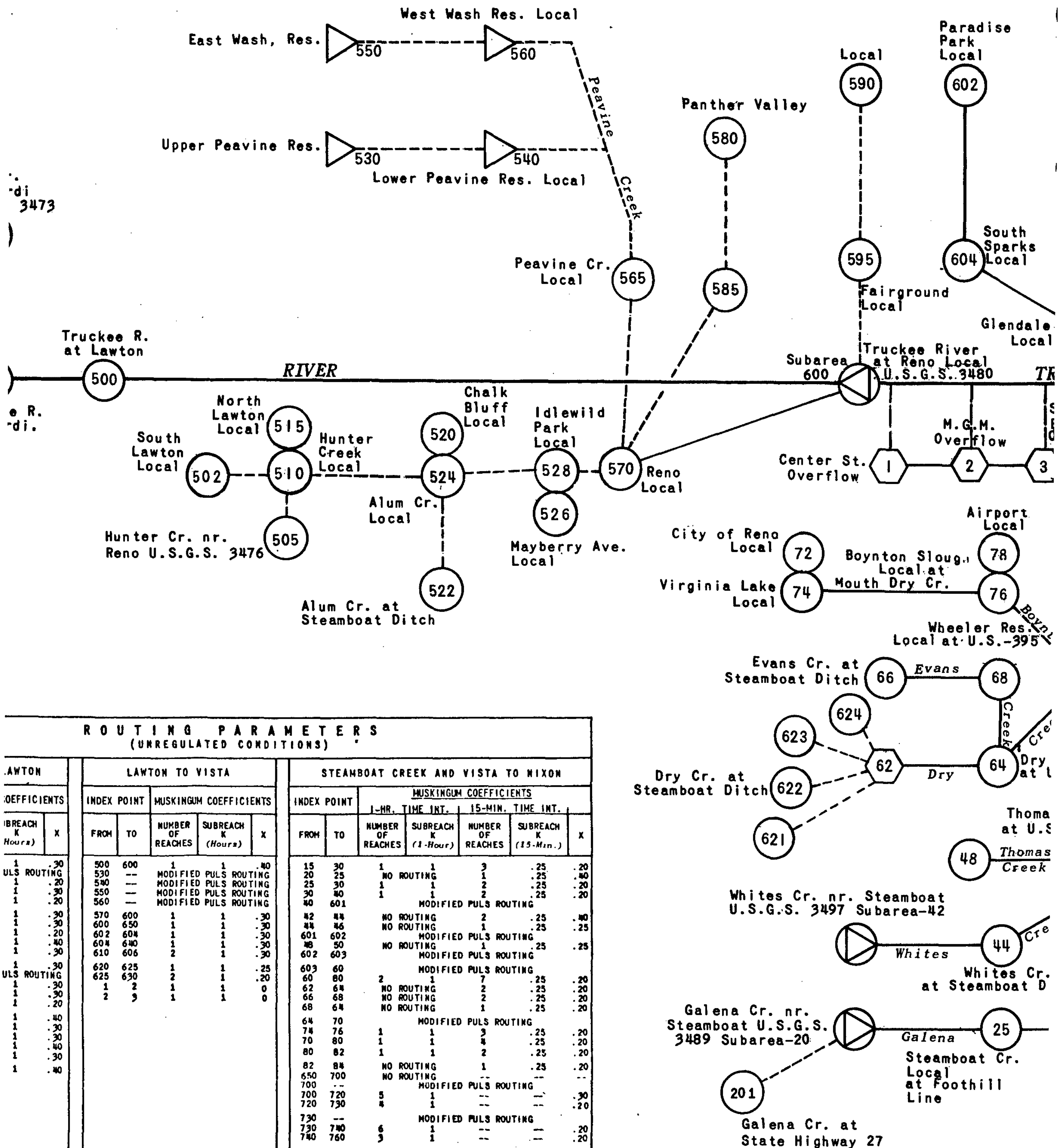
ROUTING
(UNREGULA

LAKE TAHOE TO LAWTON

INDEX POINT FROM	INDEX POINT TO	MUSKINGUM COEFFICIENTS NUMBER OF REACHES	SUBREACH K (Hours)	X
3380	50	2	1	.30
3385	—	MODIFIED PULS ROUTING		
3385	50	2	1	.20
50	100	2	1	.30
3394	100	3	1	.20
100	200	2	1	.30
3397	3403	2	1	.30
3399	3403	4	1	.20
3403	3405	1	1	.40
3405	200	2	1	.30
200	300	1	1	.30
3430	—	MODIFIED PULS ROUTING		
3430	3420	2	1	.30
3420	3443	3	1	.30
3435	3443	3	1	.20
3443	3444	1	1	.40
3444	3445	1	1	.30
300	3460	1	1	.30
3460	400	1	1	.40
3473	400	1	1	.30
400	500	1	1	.40

LAWTON TO V

INDEX POINT FROM	INDEX POINT TO	MUSKINGUM NUMBER OF REACHES
500	600	1
530	—	MODIFIED
540	—	MODIFIED
550	—	MODIFIED
560	—	MODIFIED
570	600	1
600	650	1
602	604	1
604	640	1
610	606	2
620	625	1
625	630	2
1	2	1
2	3	1

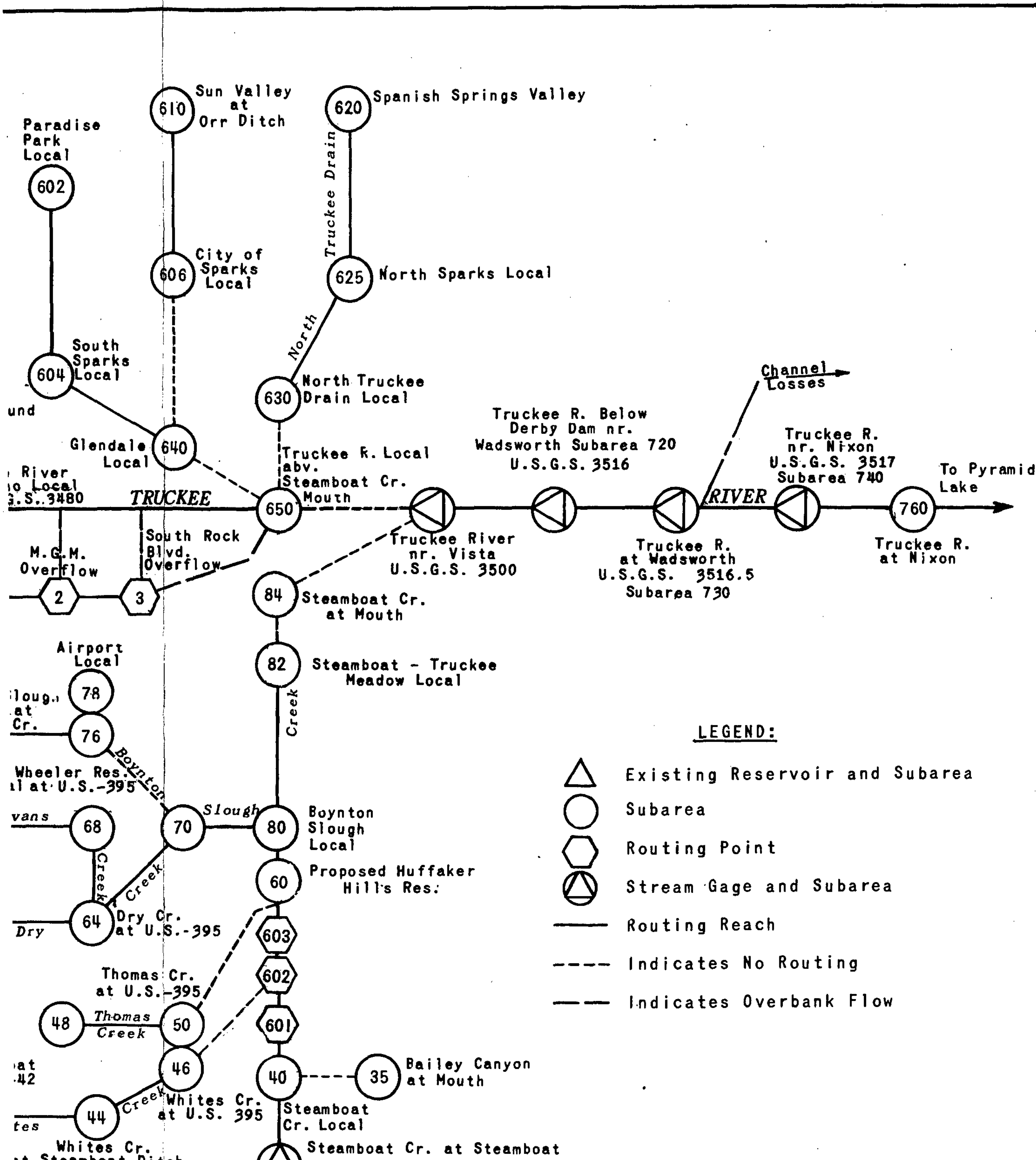


ROUTING PARAMETERS
(UNREGULATED CONDITIONS)

.AWTON	
:OEFFICIENTS	
IBREACH K (Hours)	X
1	.30
ULS ROUTING	
1	.20
1	.30
1	.20
1	.30
1	.30
1	.20
1	.40
1	.30
1	.30
ULS ROUTING	
1	.30
1	.30
1	.20
1	.40
1	.30
1	.30
1	.40
1	.30
1	.40

LAWTON TO VISTA				
INDEX POINT		MUSKINGUM COEFFICIENTS		
FROM	TO	NUMBER OF REACHES	SUBREACH K (Hours)	X
500	600	1	1	.40
530	--	MODIFIED PULS ROUTING		
540	--	MODIFIED PULS ROUTING		
550	—	MODIFIED PULS ROUTING		
560	—	MODIFIED PULS ROUTING		
570	600	1	1	.30
600	650	1	1	.30
602	604	1	1	.30
604	640	1	1	.30
610	606	2	1	.30
620	625	1	1	.25
625	630	2	1	.20
1	2	1	1	0
2	3	1	1	0

STEAMBOAT CREEK AND VISTA TO NIXON						
INDEX POINT		MUSKINGUM COEFFICIENTS				
		1-HR. TIME INT.		15-MIN. TIME INT.		
FROM	TO	NUMBER OF REACHES	SUBREACH K (1-Hour)	NUMBER OF REACHES	SUBREACH K (15-Min.)	X
15	30	1	1	3	.25	.20
20	25	NO ROUTING		1	.25	.40
25	30	1	1	2	.25	.20
30	40	1	1	2	.25	.20
40	601	MODIFIED PULS ROUTING				
42	44	NO ROUTING		2	.25	.40
44	46	NO ROUTING		1	.25	.25
601	602	MODIFIED PULS ROUTING				
48	50	NO ROUTING		1	.25	.25
602	603	MODIFIED PULS ROUTING				
603	60	MODIFIED PULS ROUTING				
60	80	2	1	7	.25	.20
62	64	NO ROUTING		2	.25	.20
66	68	NO ROUTING		2	.25	.20
68	64	NO ROUTING		1	.25	.20
64	70	MODIFIED PULS ROUTING				
74	76	1	1	3	.25	.20
70	80	1	1	4	.25	.20
80	82	1	1	2	.25	.20
82	84	NO ROUTING		1	.25	.20
650	700	NO ROUTING		--	--	--
700	--	MODIFIED PULS ROUTING				
700	720	5	1	--	--	.30
720	730	4	1	--	--	.20
730	--	MODIFIED PULS ROUTING				
730	740	6	1	--	—	.20
740	760	3	1	--	—	.20



TRUCKEE RIVER, CALIFORNIA; NEVADA

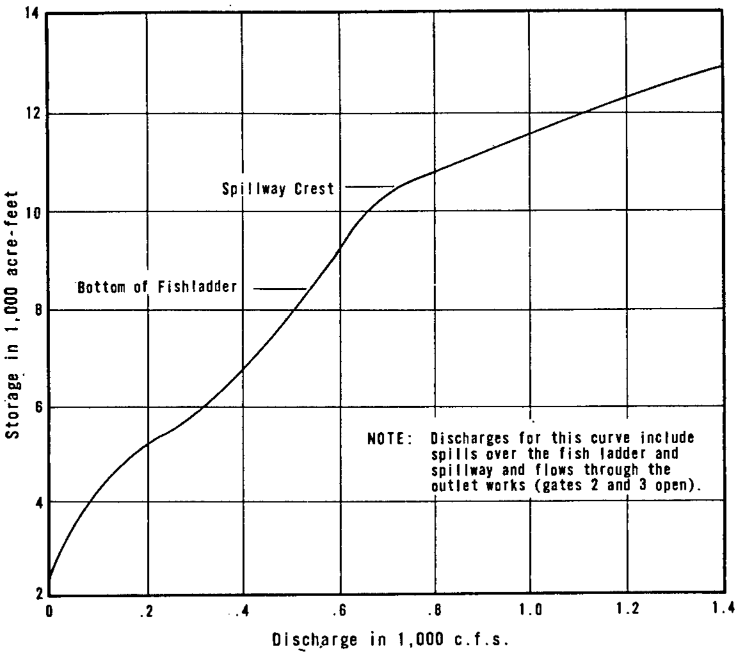
TRUCKEE RIVER SYSTEM
ROUTING DIAGRAM

CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA

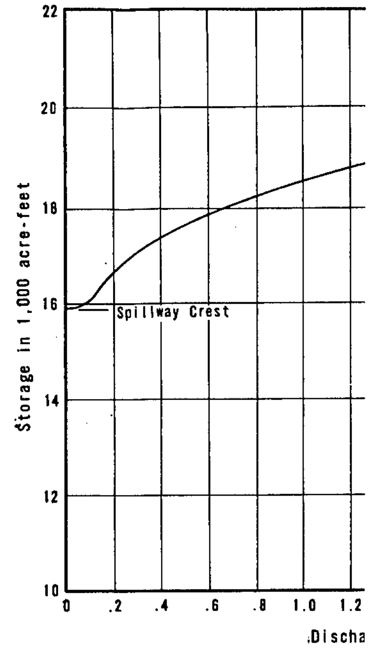
Prepared: P.W.
Drawn: C.A.P

Date: NOVEMBER 1979

CHART 14



DONNER LAKE
Index Point-3385
Donner Creek



IN

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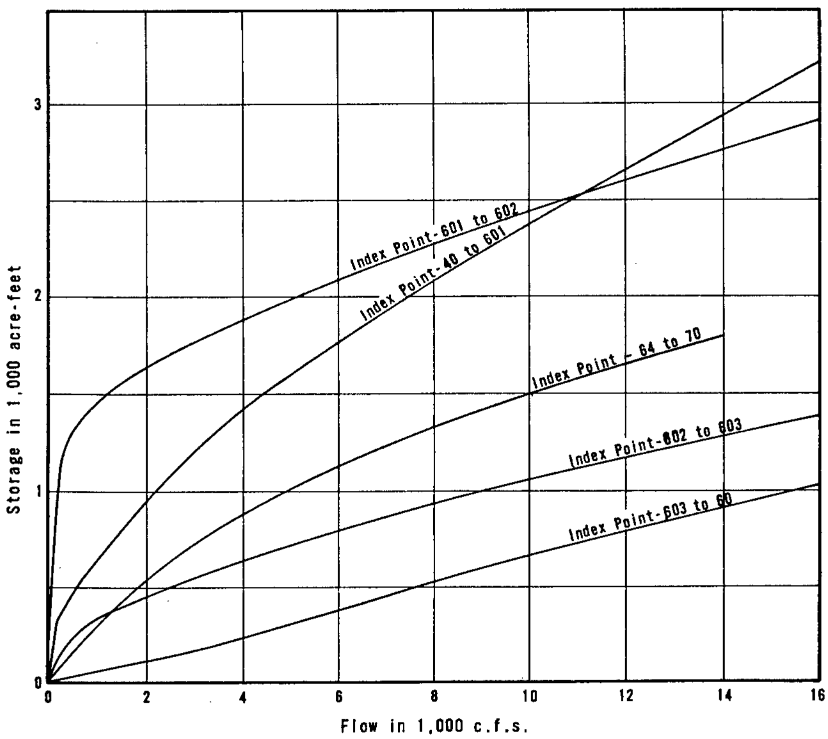
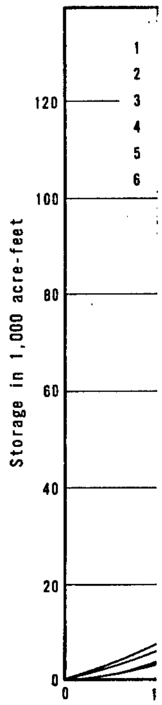
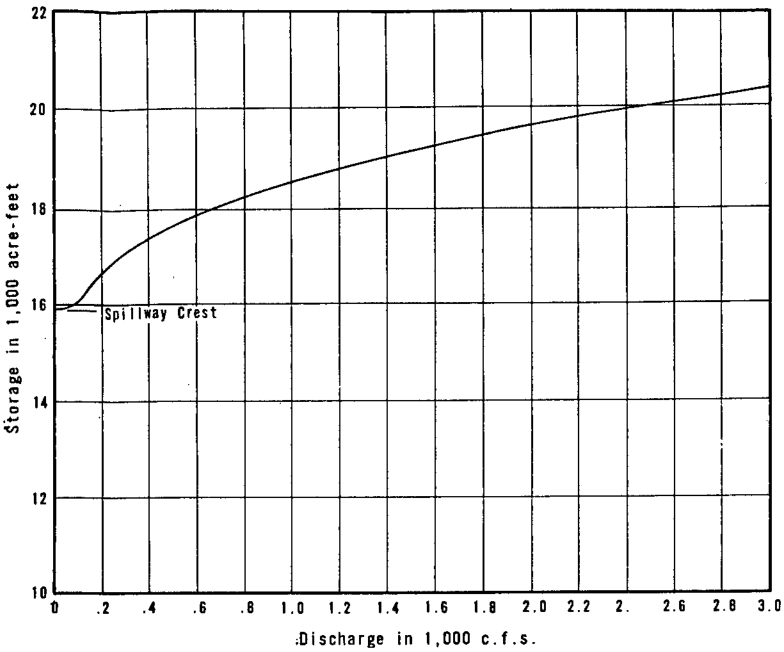
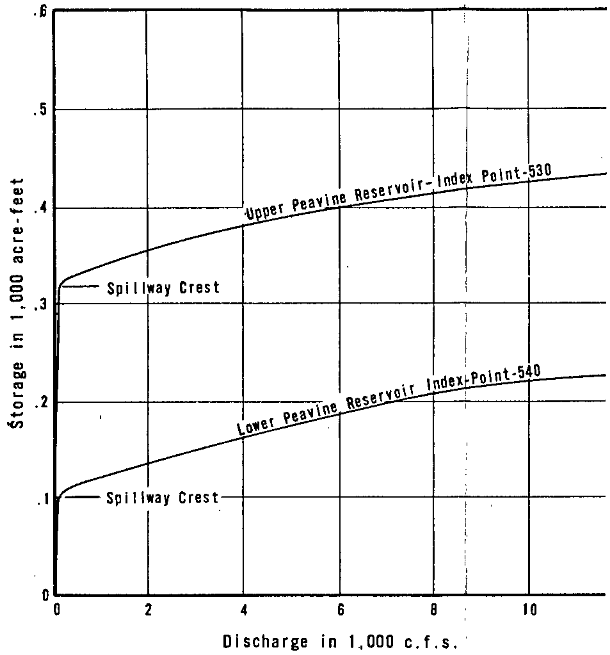


INDEX POINT 40 TO 60
Steamboat Creek - Huffacker Hills Area
and Dry Creek above Boynton Slough

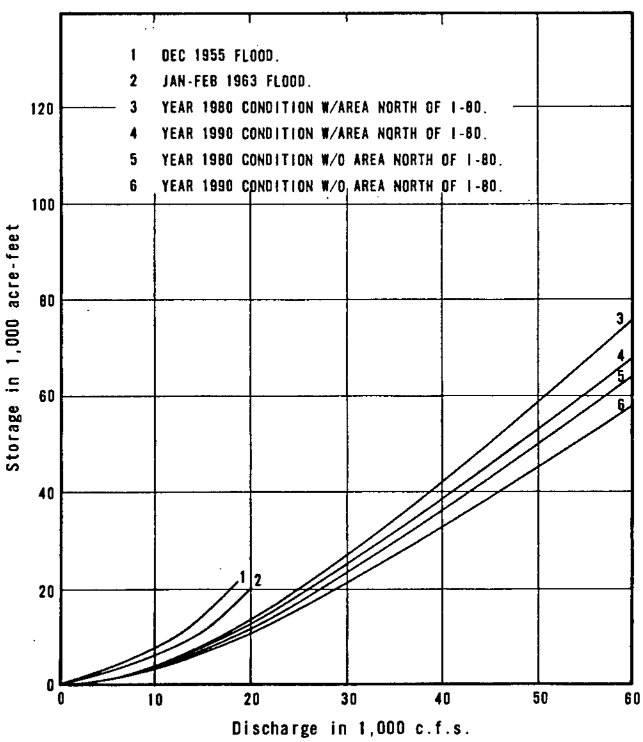




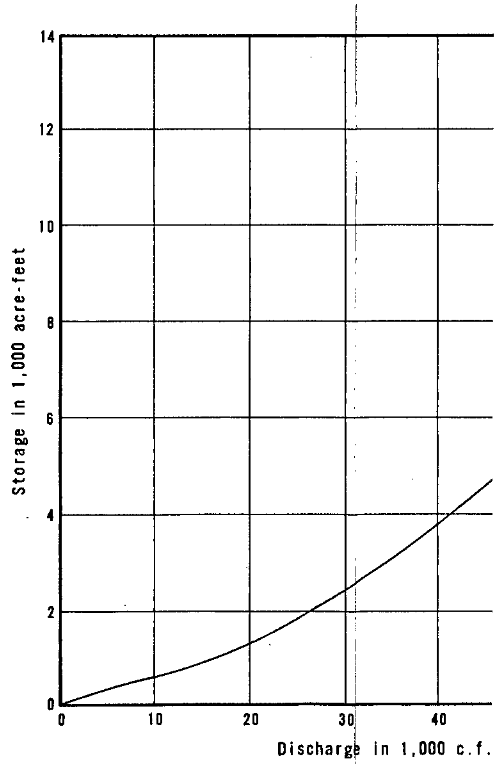
INDEPENDENCE LAKE
Index Point-3430
Independence Creek



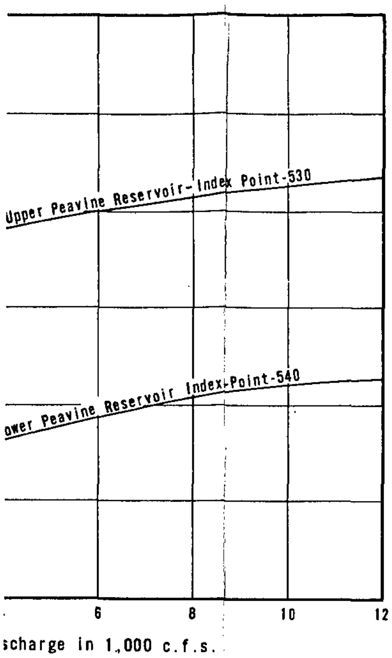
UPPER & LOWER PEAVINE RESERVOIRS
Peavine Creek



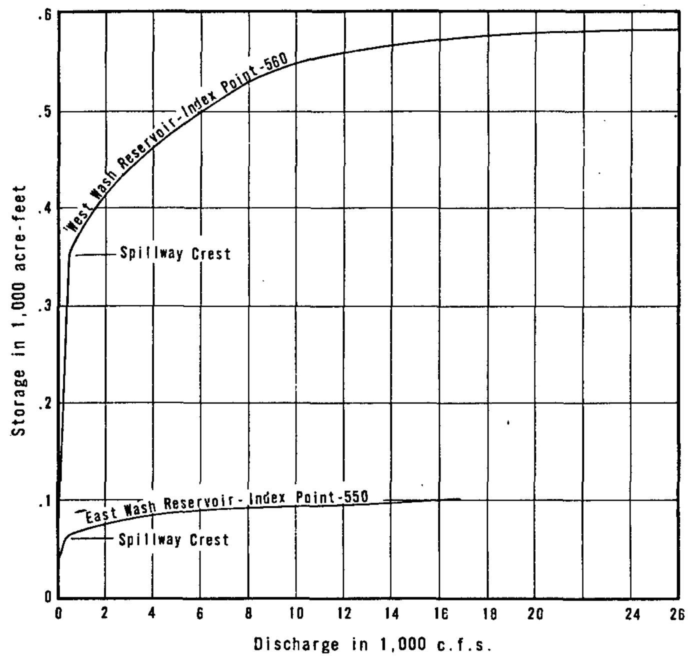
TRUCKEE RIVER AT VISTA, NEVADA
Index Point-700
(Truckee Meadows Area)



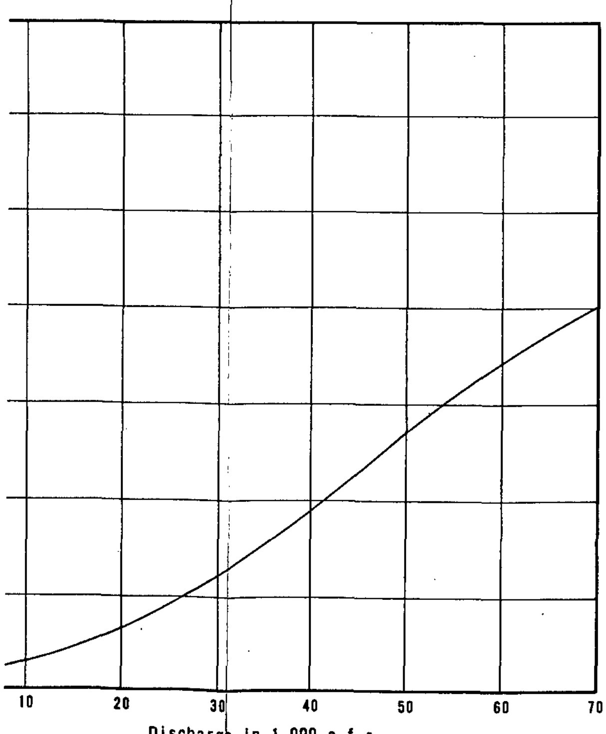
TRUCKEE RIVER AT WADSWOF
Index Point-730
(Old Highway 40 Bridge)



& LOWER PEAVINE RESERVOIRS
Peavine Creek



EAST & WEST WASH RESERVOIRS



TRUCKEE RIVER AT WADSWORTH
Index Point-730
(Old Highway 40 Bridge)

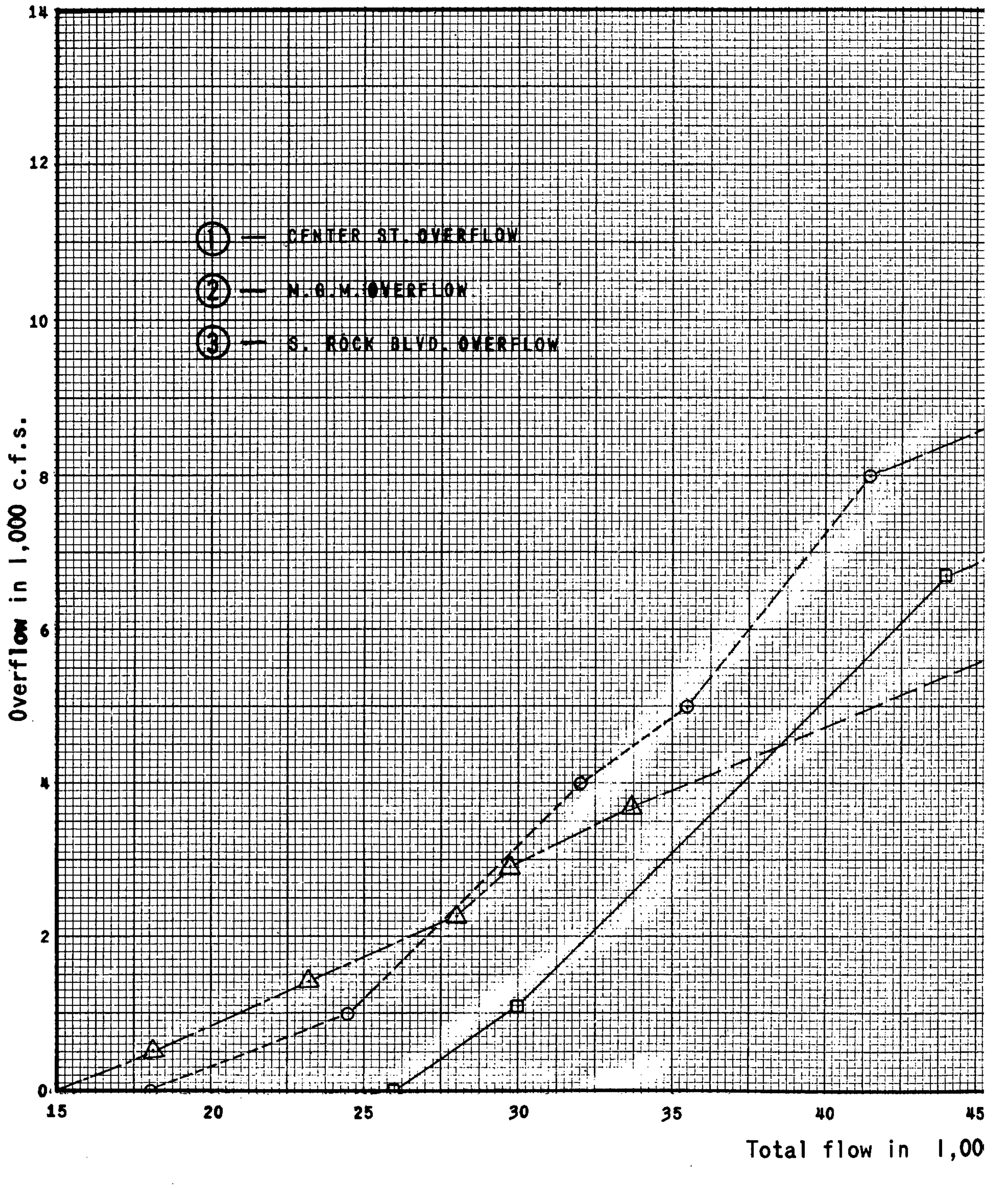
TRUCKEE RIVER, CALIFORNIA;NEVADA

STORAGE-OUTFLOW RELATIONSHIPS

CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA

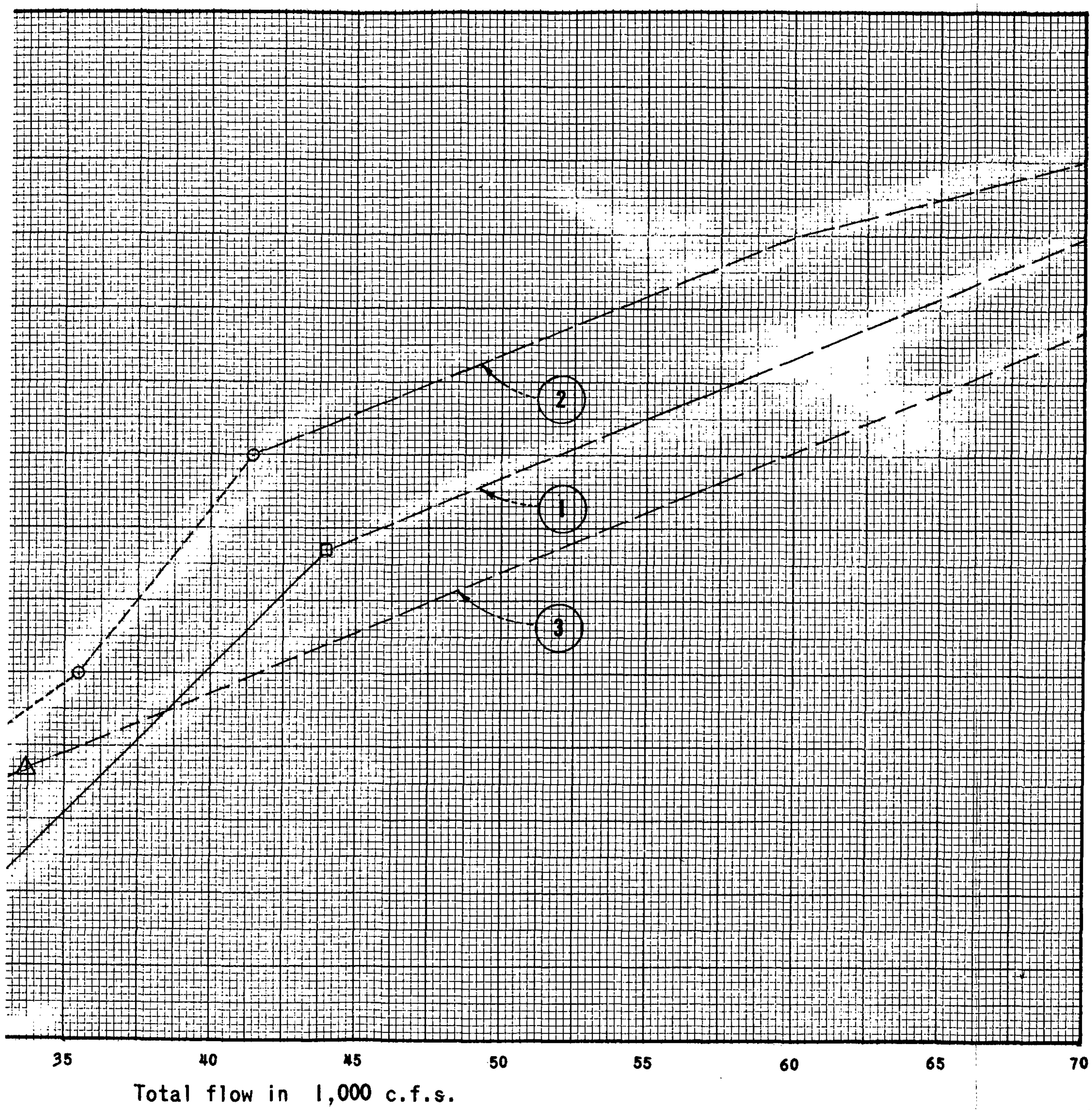
Prepared: P.W.
Drawn: C.A.P.
Date: NOVEMBER 1979

CHART 15



① — CENTER ST. OVERFLOW
② — N.G.M. OVERFLOW
③ — S. ROCK BLVD. OVERFLOW
Overflow in 1,000 c.f.s.
Total flow in 1,00
0
2
4
6
8
10
12
14
15
20
25
30
35
40
45

1



NOTE:
Plotted points based on computed water surface profiles. Upper portion of curves estimated.

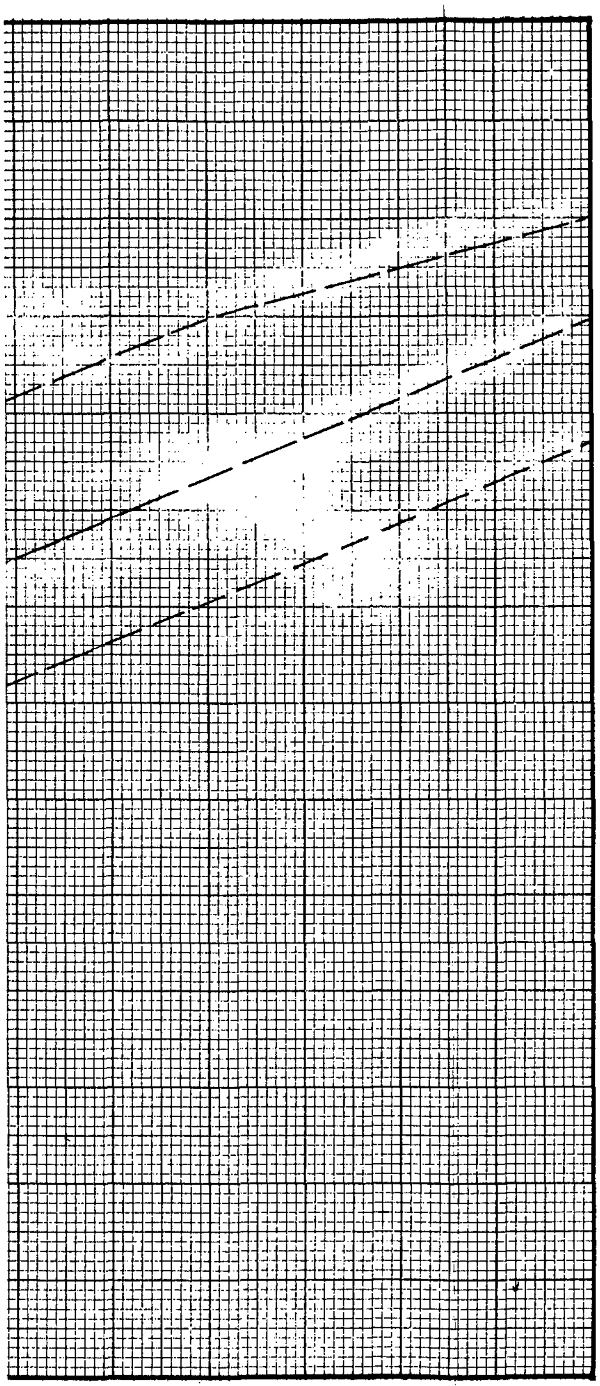
TRUCK

TO

T

CORPS OF

Prepared:
Drawn: J.



points based on computed water
profiles. Upper portion of
estimated.

TRUCKEE RIVER, CALIFORNIA; NEVADA

TOTAL FLOW TO OVERFLOW
RELATIONSHIPS

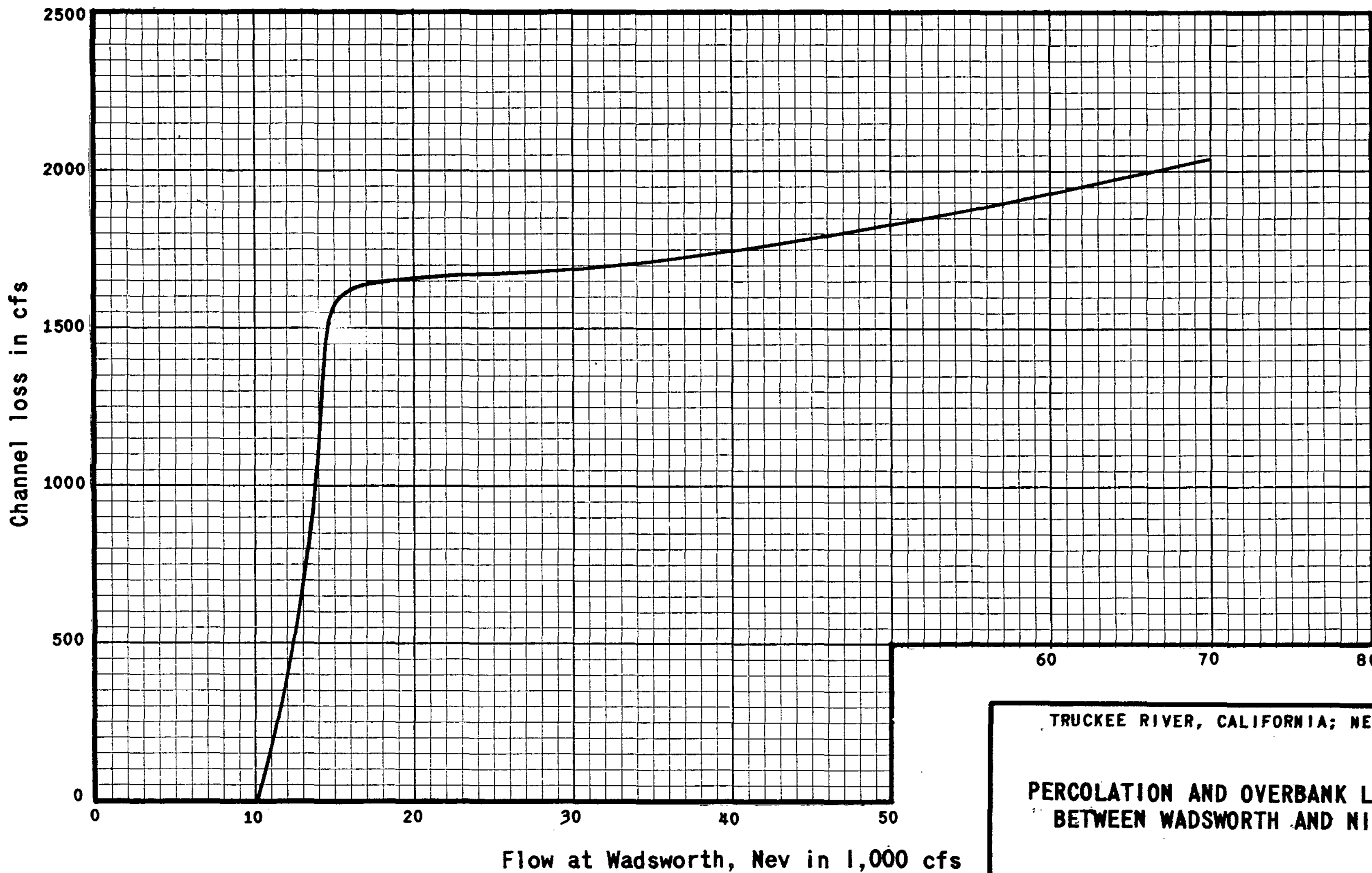
TRUCKEE RIVER AT RENO

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: J.H.

Date: NOVEMBER 1979

CHART 16



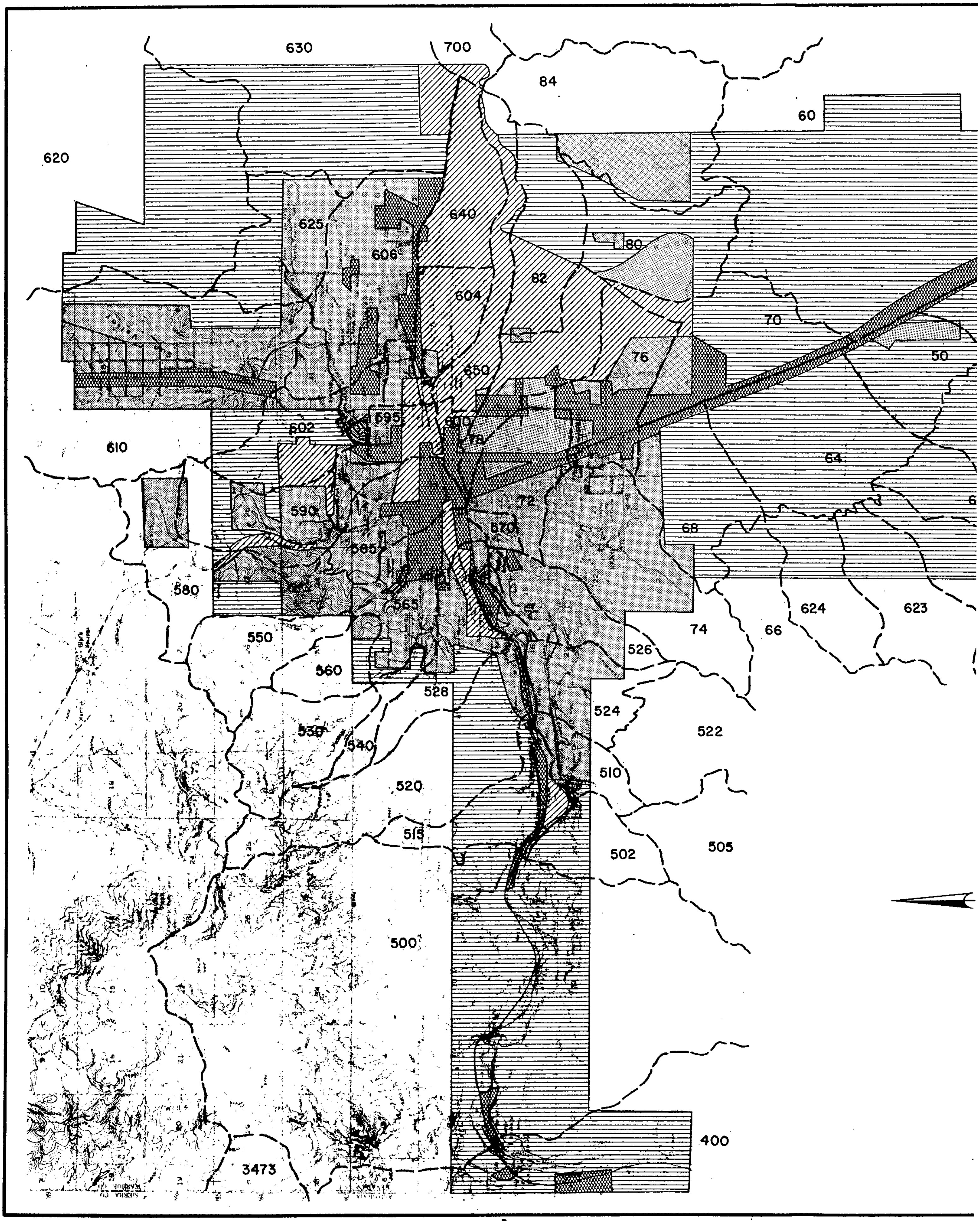
TRUCKEE RIVER, CALIFORNIA; NEVADA

PERCOLATION AND OVERBANK LOSSES BETWEEN WADSWORTH AND NIXON

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: J.H.
Date: NOVEMBER 1979

CHART 17



630
700
84
60
620
640
625
606
80
82
604
70
50
76
650
595
600
602
78
610
64
72
590
570
585
68
580
565
624
623
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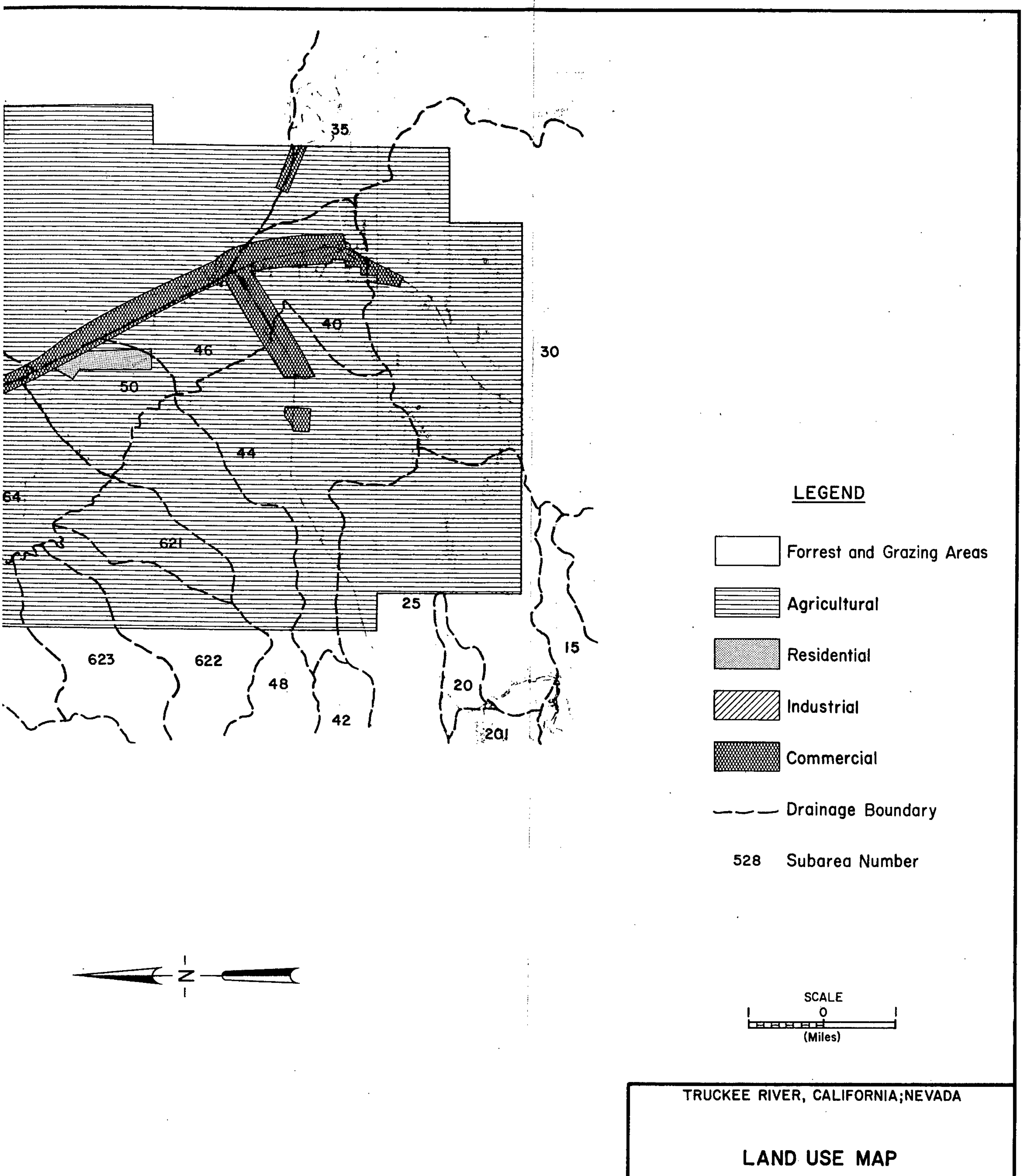
502
505
500
400
3473



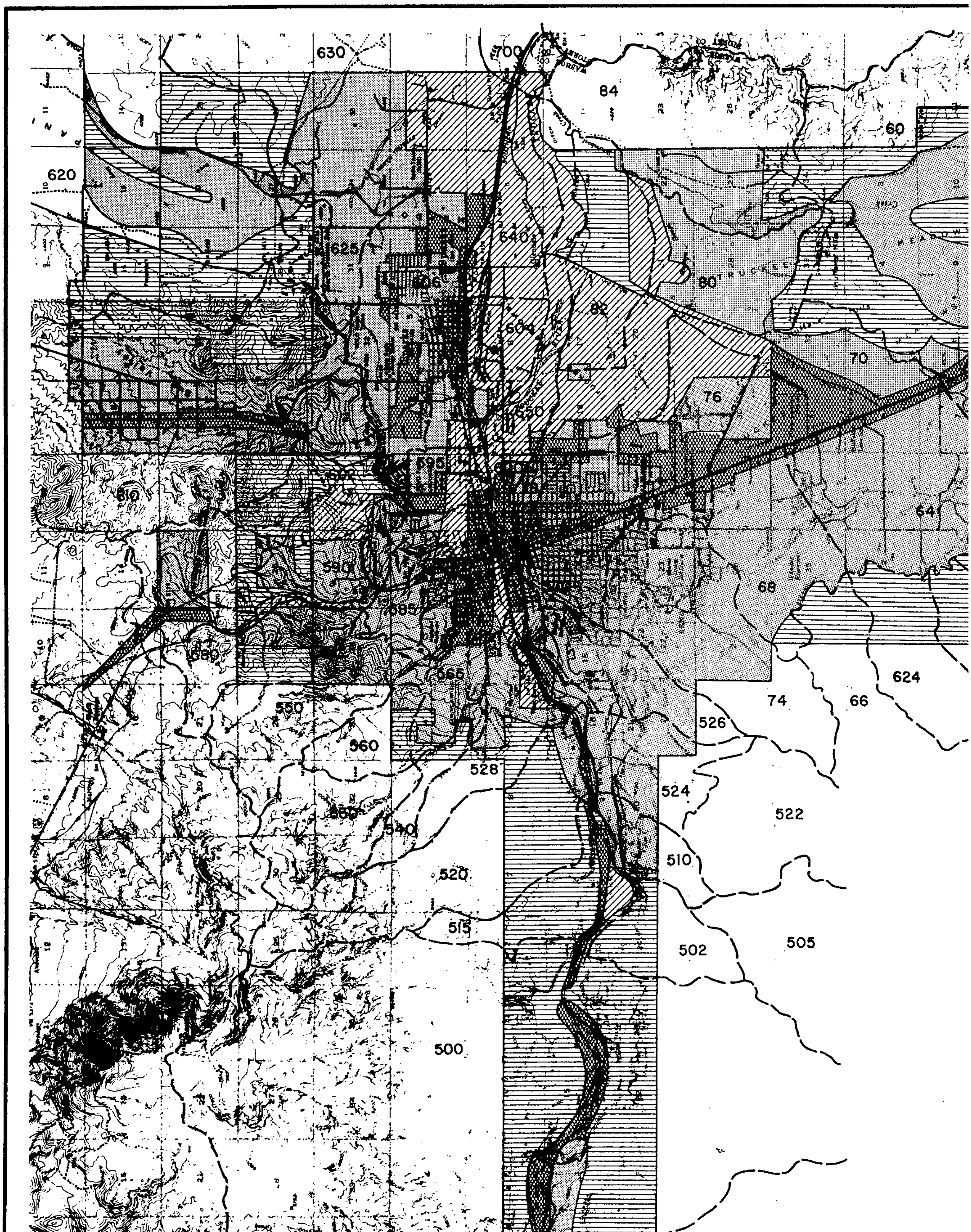
TRUCKEE RIVER, CALIFORNIA;NEVADA

LAND USE MAP
YEAR 1980 CONDITIONS
RENO AREA

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: C.A.P.
Date: NOVEMBER 1979

CHART 18



630
700
84
60
620
640
625
606
80
82
604
70
76
650
595
600
610
64
590
68
585
580
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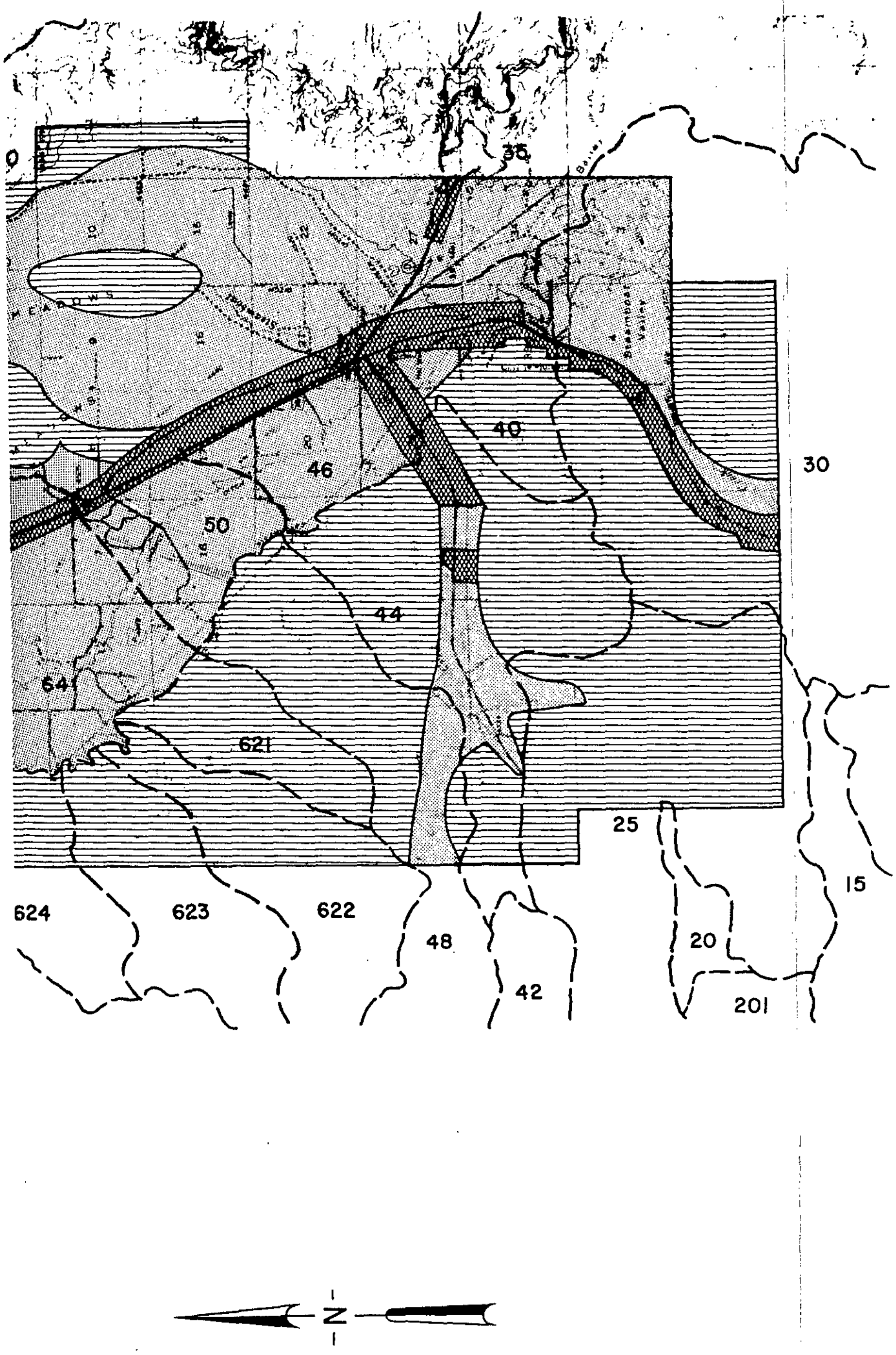
515
502
505
500
400
3473



LEGEND

- Forrest and Grazing Areas
- Agricultural
- Residential
- Industrial
- Commercial
- Drainage Boundary
- 528 Subarea Number

SCALE
0
(Miles)

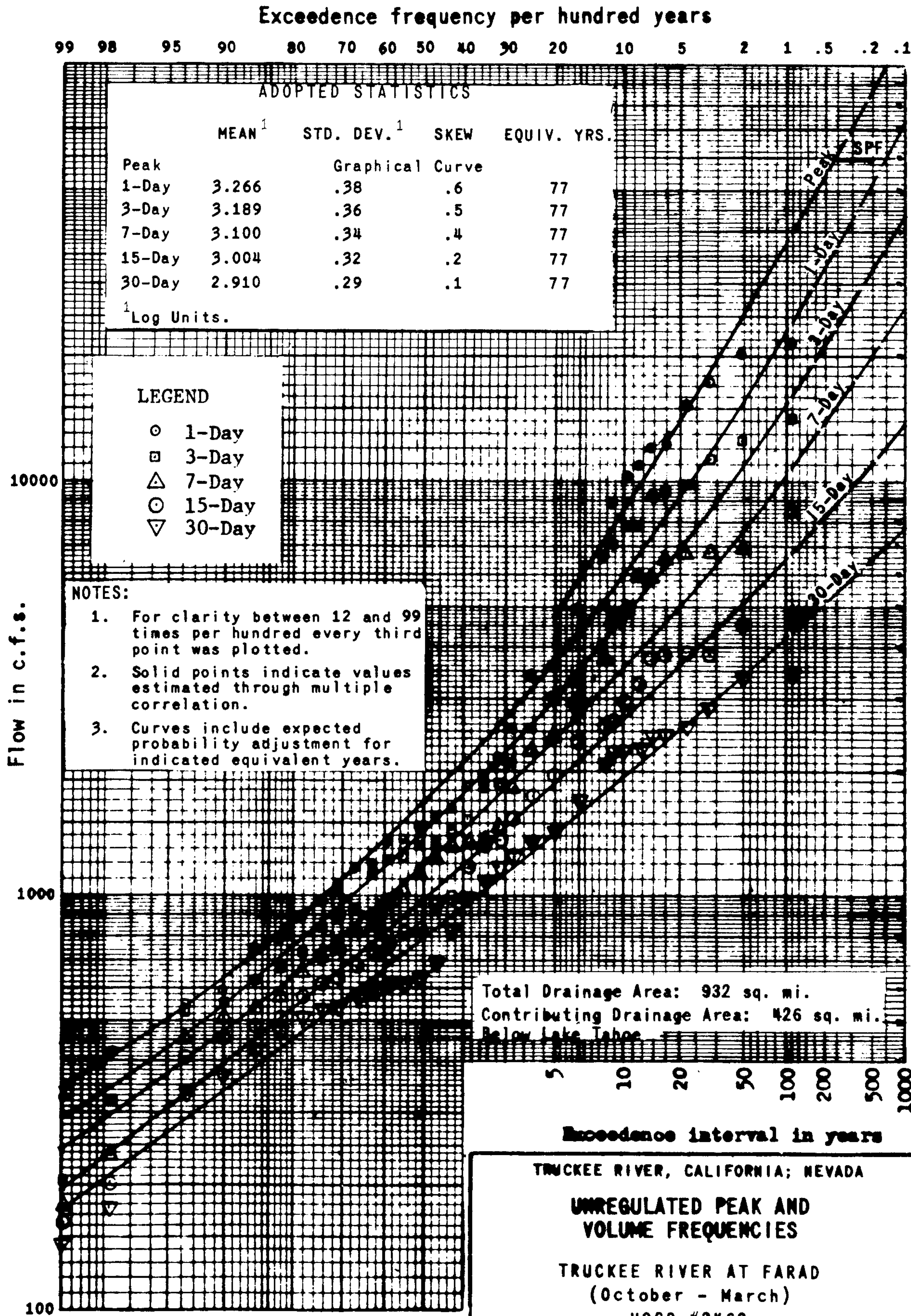
TRUCKEE RIVER, CALIFORNIA;NEVADA

LAND USE MAP
YEAR 1990 CONDITIONS
RENO AREA

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: C.A.P.
Date: NOVEMBER 1979

CHART 19



ADOPTED STATISTICS

	MEAN[1]	STD. DEV.[1]	SKEW	EQUIV. YRS.
Peak		Graphical	Curve	
1-Day	3.266	.38	.6	77
3-Day	3.189	.36	.5	77
7-Day	3.100	.34	.4	77
15-Day	3.004	.32	.2	77
30-Day	2.910	.29	.1	77

[1] Log Units.

NOTES:

1. For clarity between 12 and 99 times per hundred years every third point was plotted.
2. Solid points indicate values estimated through multiple correlation.
3. Curves include expected probability adjustment for indicated equivalent years.

Period of record used in analysis: 1902-1977

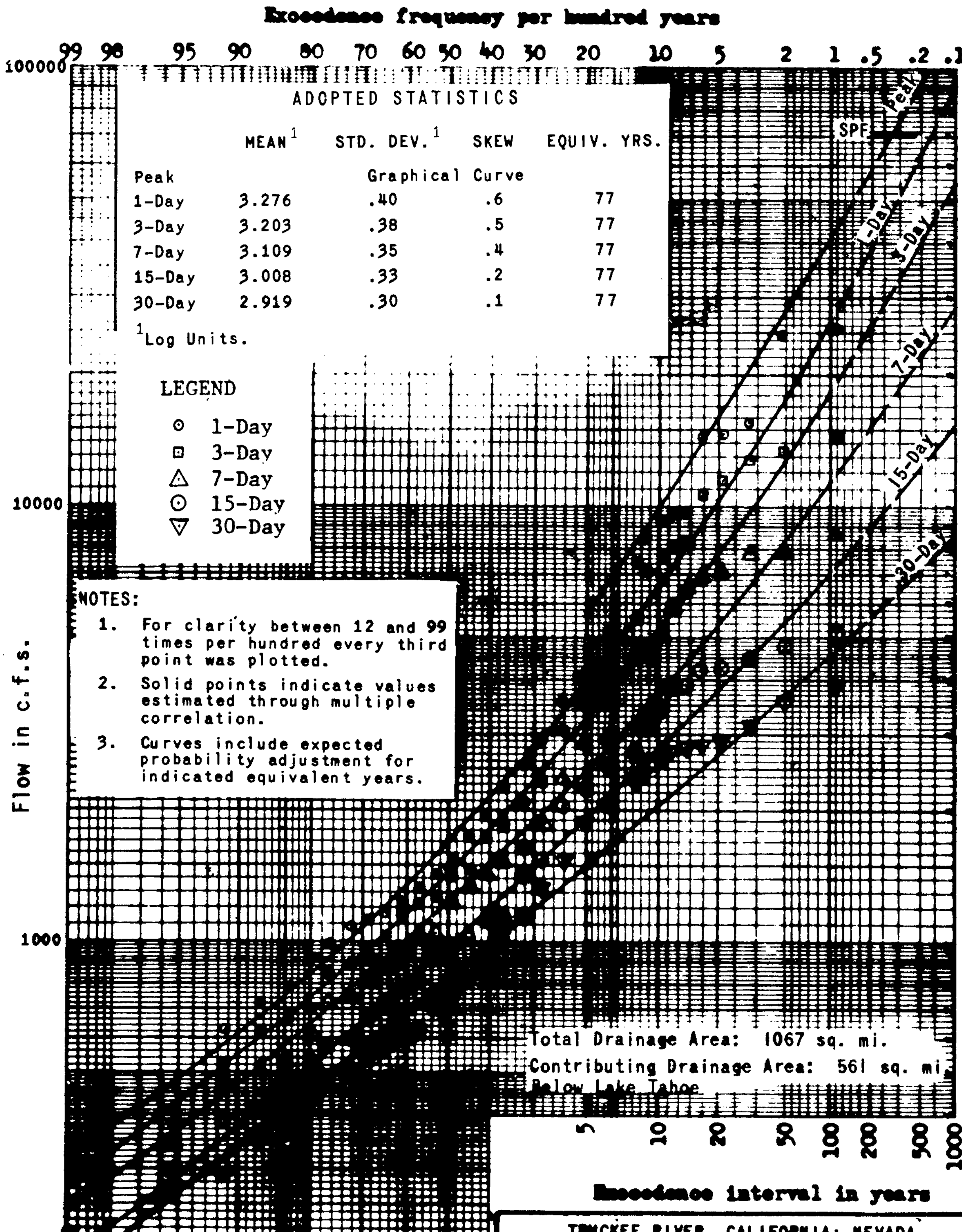
TRUCKEE RIVER, CALIFORNIA; NEVADA

UNREGULATED PEAK AND VOLUME FREQUENCIES

TRUCKEE RIVER AT FARAD
(October - March)
USGS #3460

Corps of Engineers, Sacramento, Calif.

Prepared: J.H. **Date:** NOVEMBER 1979



ADOPTED STATISTICS

	MEAN[1]	STD. DEV.[1]	SKEW	EQUIV. YRS.
Peak		Graphical	Curve	
1-Day	3.276	.40	.6	77
3-Day	3.203	.38	.5	77
7-Day	3.109	.35	.4	77
15-Day	3.008	.33	.2	77
30-Day	2.919	.30	.1	77

[1] Log Units.

LEGEND

- ⊙ 1-Day
- ⊡ 3-Day
- △ 7-Day
- ⊙ 15-Day
- ▽ 30-Day

NOTES:

1. For clarity between 12 and 99 times per hundred every third point was plotted.
2. Solid points indicate values estimated through multiple correlation.
3. Curves include expected probability adjustment for indicated equivalent years.

Total Drainage Area: 1067 sq. mi.
Contributing Drainage Area: 561 sq. mi.
Below Lake Tahoe

Period of record used in analysis: 1907, 09-10, 13-19, 31-34, 43, 46-77.

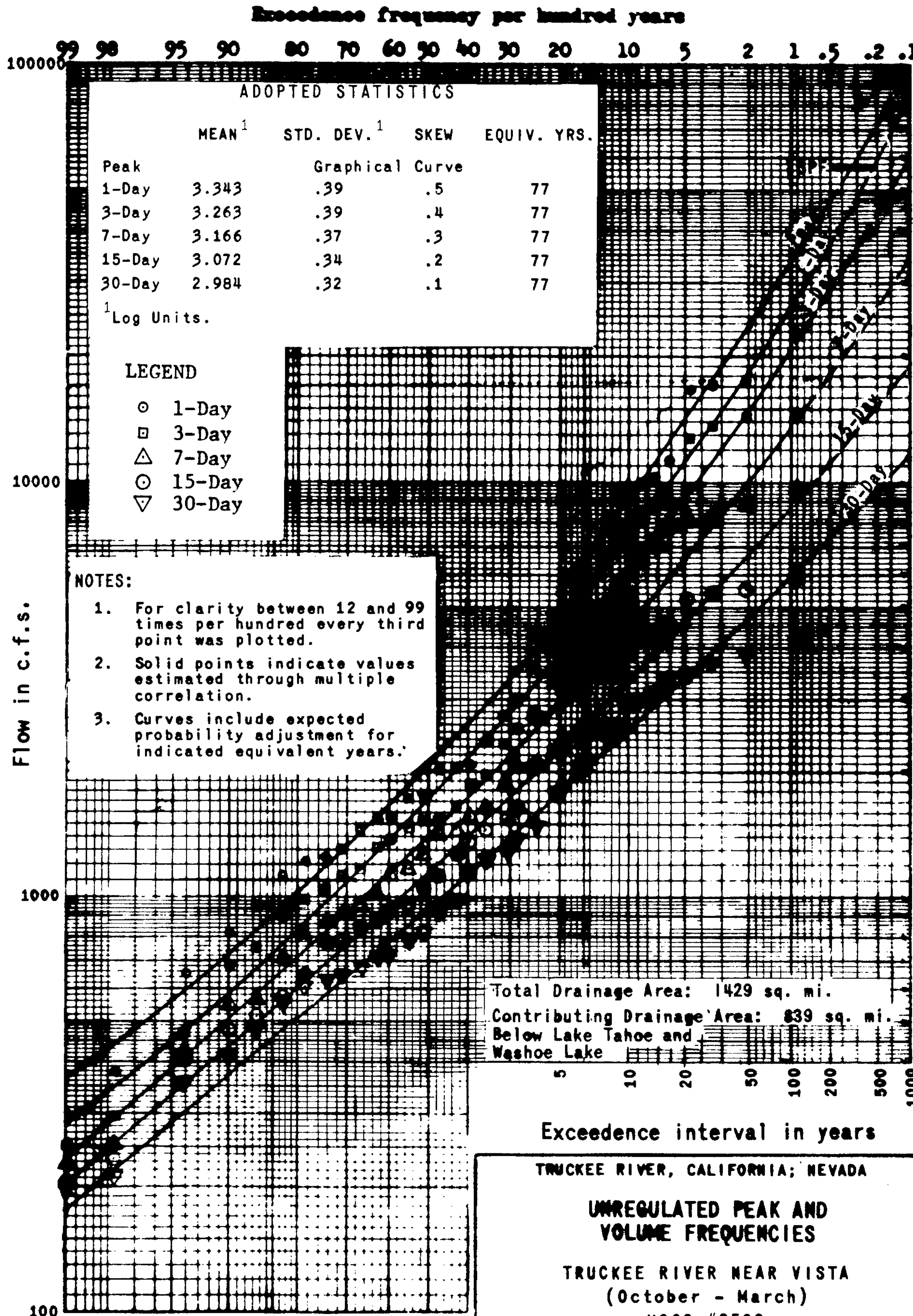
TRUCKEE RIVER, CALIFORNIA; NEVADA

UNREGULATED PEAK AND VOLUME FREQUENCIES

TRUCKEE RIVER AT RENO
(October - March)
USGS #3480

Corps of Engineers, Sacramento, Calif.

Prepared: J.H. Date: NOVEMBER 1979



ADOPTED STATISTICS

	MEAN[1]	STD. DEV.[1]	SKEW	EQUIV. YRS.
Peak		Graphical	Curve	
1-Day	3.343	.39	.5	77
3-Day	3.263	.39	.4	77
7-Day	3.166	.37	.3	77
15-Day	3.072	.34	.2	77
30-Day	2.984	.32	.1	77

[1] Log Units.

NOTES:

1. For clarity between 12 and 99 times per hundred every third point was plotted.
2. Solid points indicate values estimated through multiple correlation.
3. Curves include expected probability adjustment for indicated equivalent years.

Total Drainage Area: 1429 sq. mi.
Contributing Drainage Area: 839 sq. mi.
Below Lake Tahoe and Washoe Lake

Period of record used in analysis: 1901-07, 33-48, 50-54, 59-77.

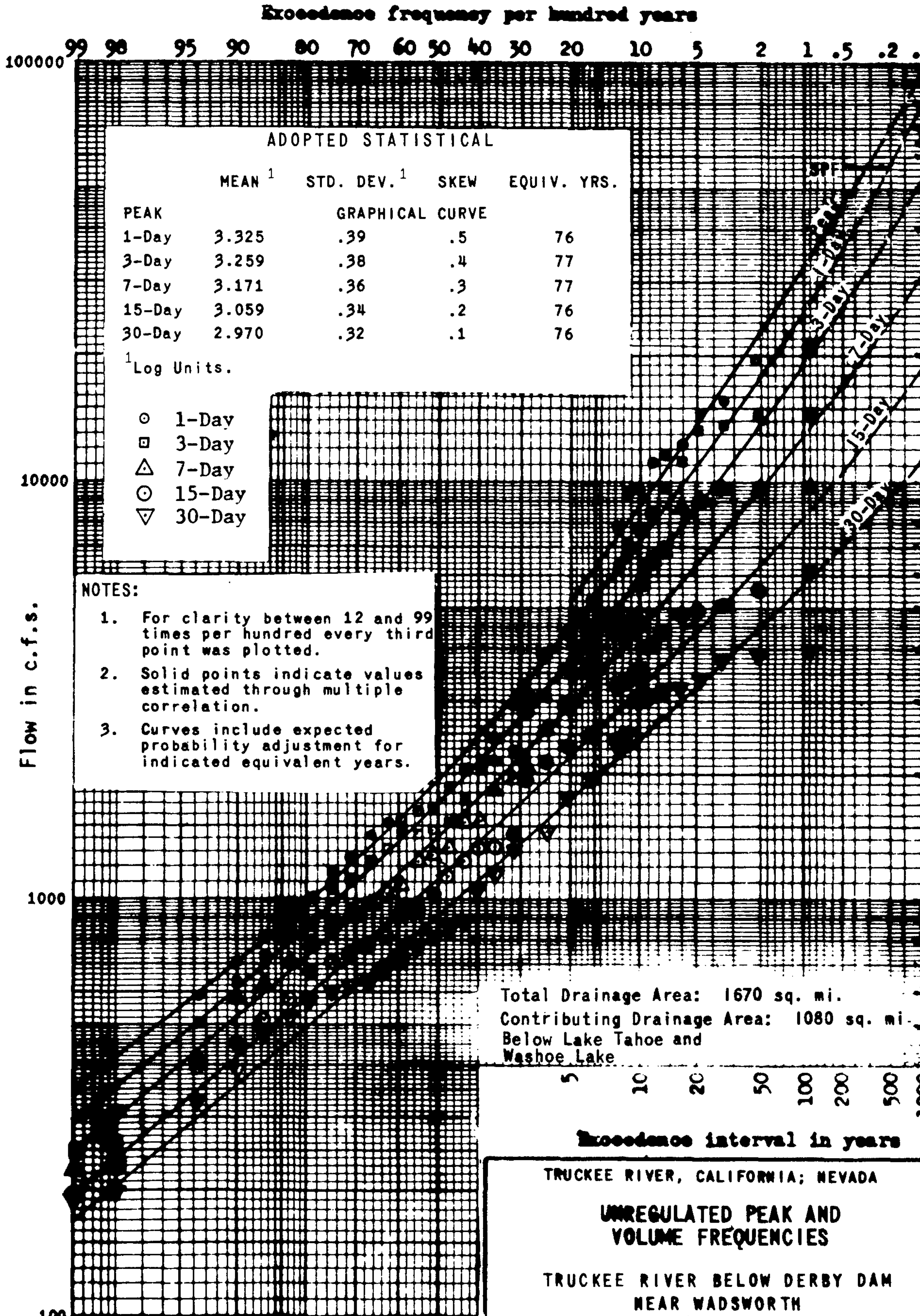
TRUCKEE RIVER, CALIFORNIA; NEVADA

UNREGULATED PEAK AND VOLUME FREQUENCIES

TRUCKEE RIVER NEAR VISTA
(October - March)
USGS #3500

Corps of Engineers, Sacramento, Calif.

Prepared: J.H. **Date**: NOVEMBER 1979



ADOPTED STATISTICAL

	MEAN [1]	STD. DEV. [1]	SKEW	EQUIV. YRS.
PEAK		GRAPHICAL CURVE		
1-Day	3.325	.39	.5	76
3-Day	3.259	.38	.4	77
7-Day	3.171	.36	.3	77
15-Day	3.059	.34	.2	76
30-Day	2.970	.32	.1	76

[1] Log Units.

⊙ 1-Day
⊡ 3-Day
△ 7-Day
⊙ 15-Day
▽ 30-Day

NOTES:

1. For clarity between 12 and 99 times per hundred every third point was plotted.
2. Solid points indicate values estimated through multiple correlation.
3. Curves include expected probability adjustment for indicated equivalent years.

Period of record used in analysis: 1919-54, 67-77.

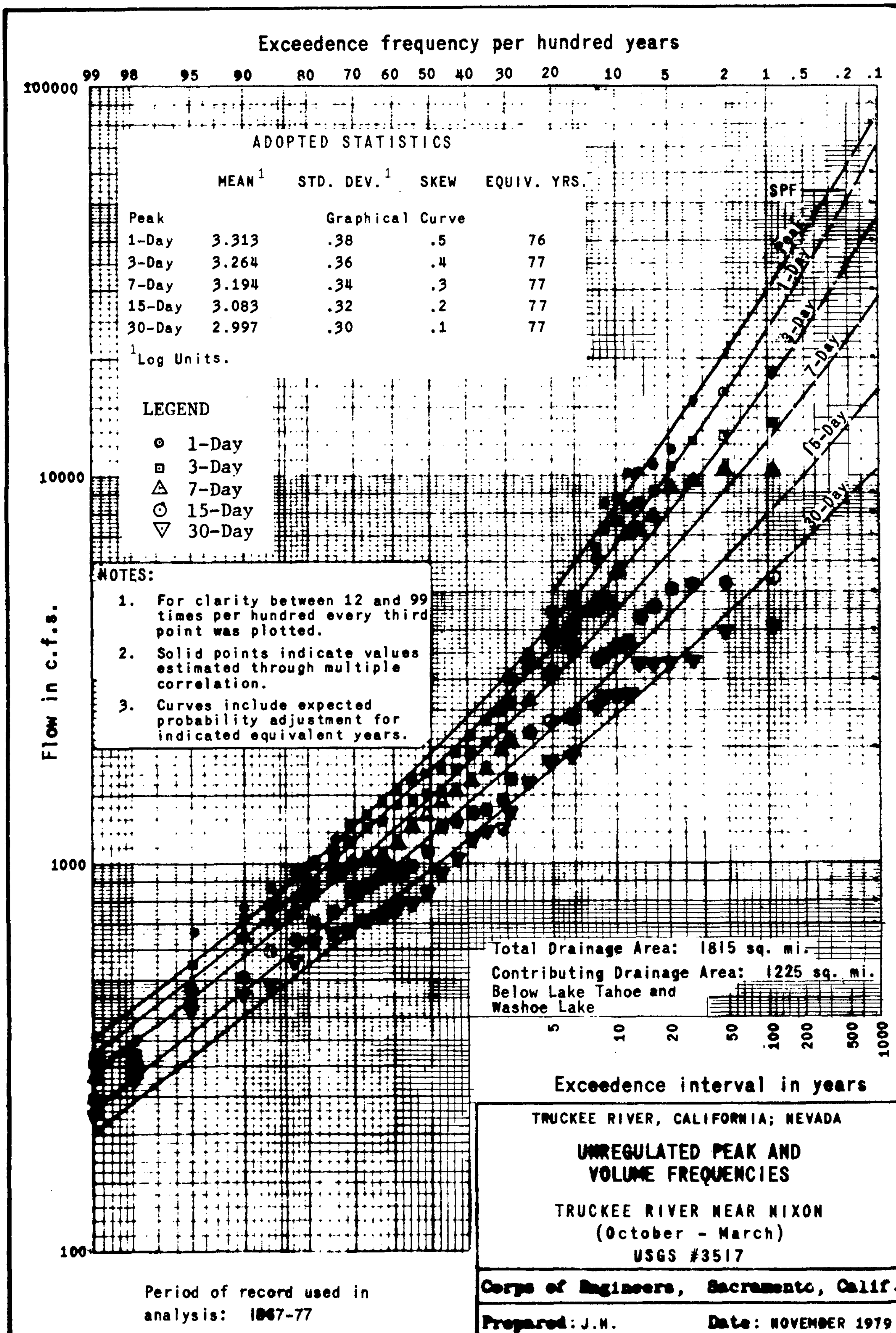
TRUCKEE RIVER, CALIFORNIA; NEVADA

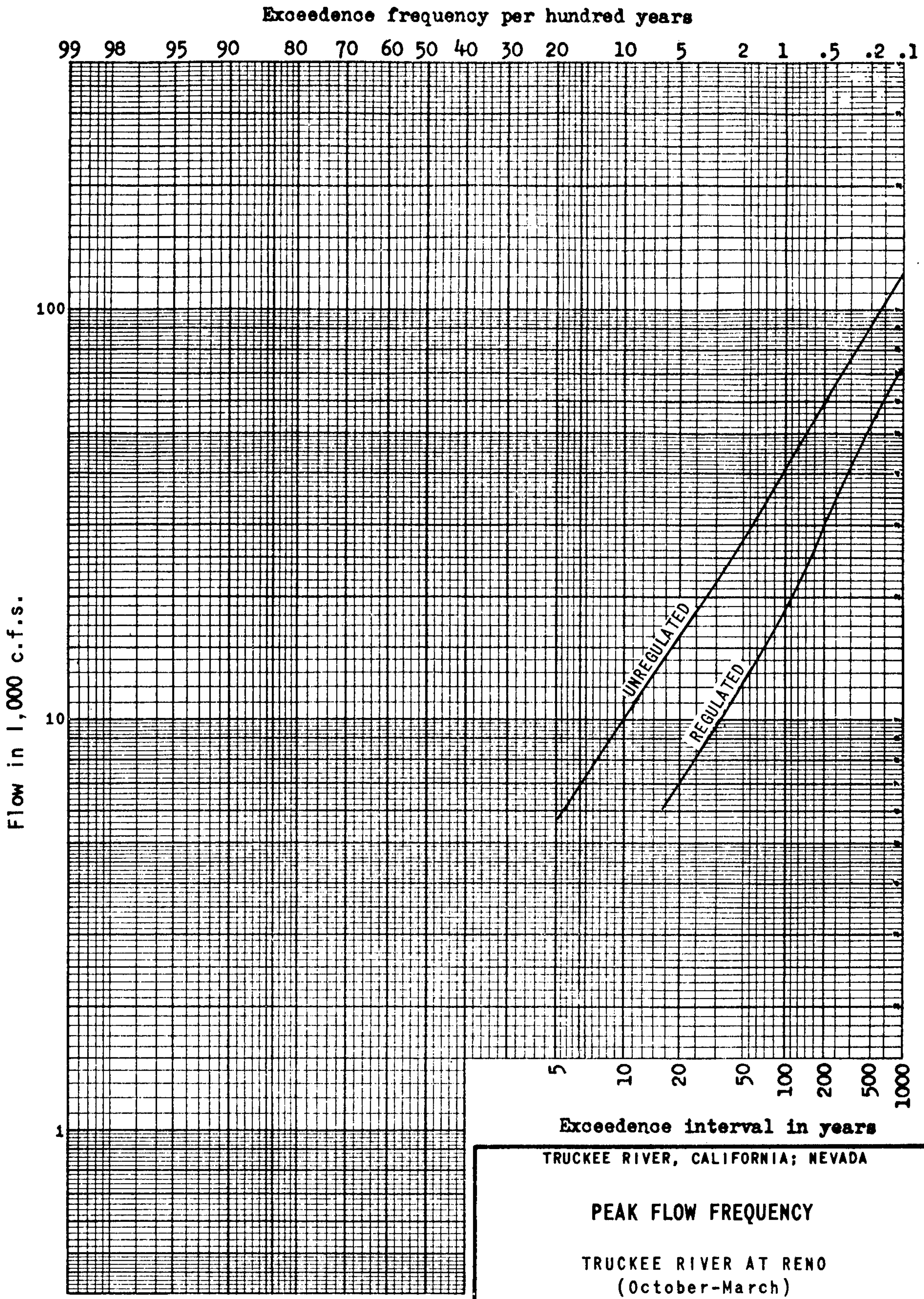
UNREGULATED PEAK AND VOLUME FREQUENCIES

TRUCKEE RIVER BELOW DERBY DAM
NEAR WADSWORTH
USGS #3516 (October - March)

Corps of Engineers, Sacramento, Calif.

Prepared: J.H. **Date:** NOVEMBER 1979


Exceedence frequency per hundred years
99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 .5 .2 .1
100000
10000
1000
100
Flow in c.f.s.
ADOPTED STATISTICS
MEAN[1] STD. DEV.[1] SKEW EQUIV. YRS.
Peak Graphical Curve
1-Day 3.313 .38 .5 76
3-Day 3.264 .36 .4 77
7-Day 3.194 .34 .3 77
15-Day 3.083 .32 .2 77
30-Day 2.997 .30 .1 77
[1]Log Units.
LEGEND
1-Day
3-Day
7-Day
15-Day
30-Day
NOTES:
1. For clarity between 12 and 99 times per hundred every third point was plotted.
2. Solid points indicate values estimated through multiple correlation.
3. Curves include expected probability adjustment for indicated equivalent years.
SPF
Peak
1-Day
3-Day
7-Day
15-Day
30-Day
Total Drainage Area: 1815 sq. mi.
Contributing Drainage Area: 1225 sq. mi.
Below Lake Tahoe and Washoe Lake
5 10 20 50 100 200 500 1000
Exceedence interval in years
TRUCKEE RIVER, CALIFORNIA; NEVADA
UNREGULATED PEAK AND VOLUME FREQUENCIES
TRUCKEE RIVER NEAR NIXON
(October - March)
USGS #3517
Corps of Engineers, Sacramento, Calif.
Prepared: J.H. Date: NOVEMBER 1979
Period of record used in analysis: 1867-77



Total Drainage Area: 1067 sq. mi.

Contributing Drainage Area: 561 sq. mi.
Below Lake Tahoe

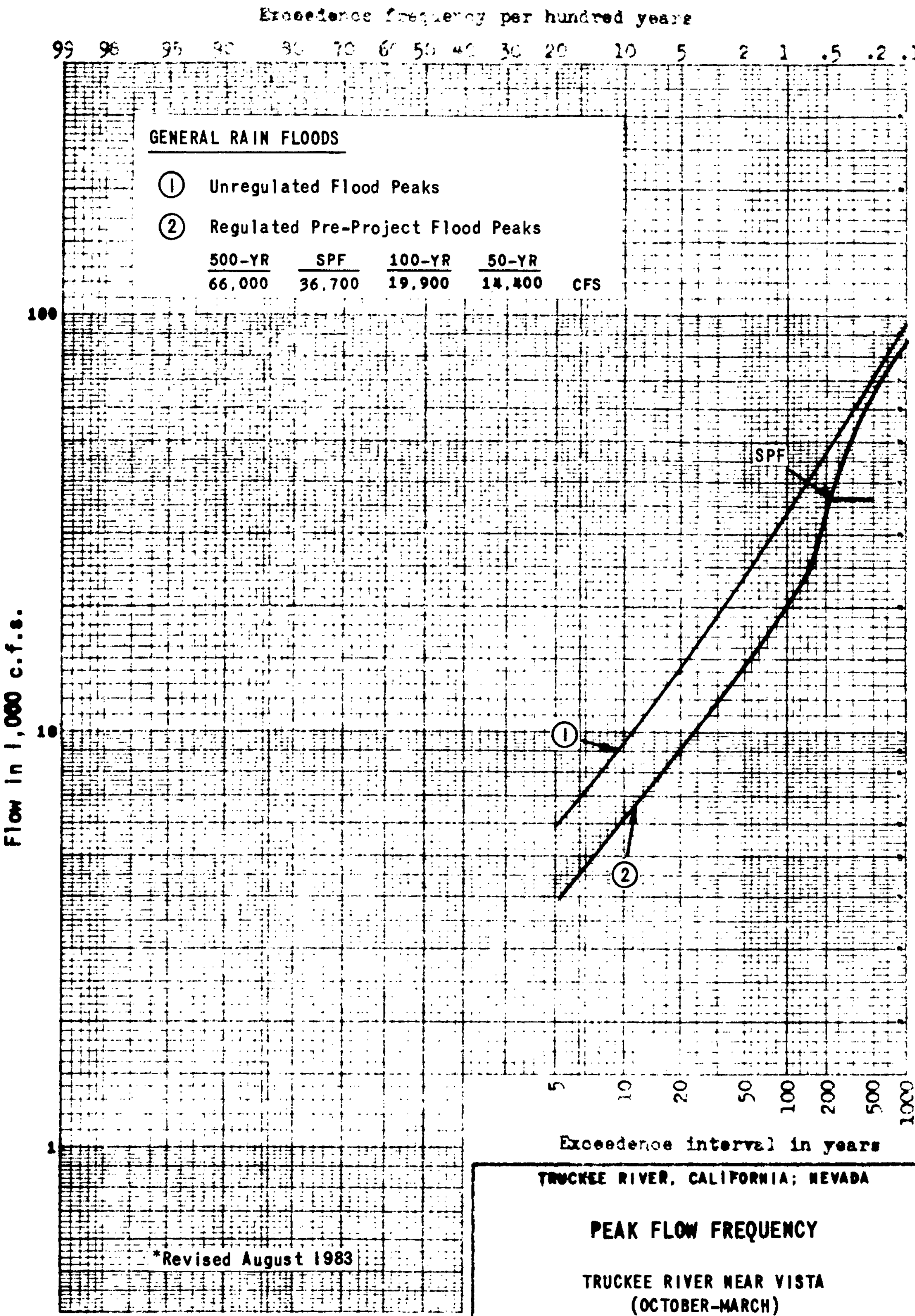
TRUCKEE RIVER, CALIFORNIA; NEVADA

PEAK FLOW FREQUENCY

TRUCKEE RIVER AT RENO
(October-March)
USGS #3480

Corps of Engineers, Sacramento, Calif.

Prepared: J.H. **Date:** NOVEMBER 1979



Total Drainage Area: 1429 sq. mi.
Contributing Drainage Area: 839 sq. mi.
Below Lake Tahoe and Washoe Lake

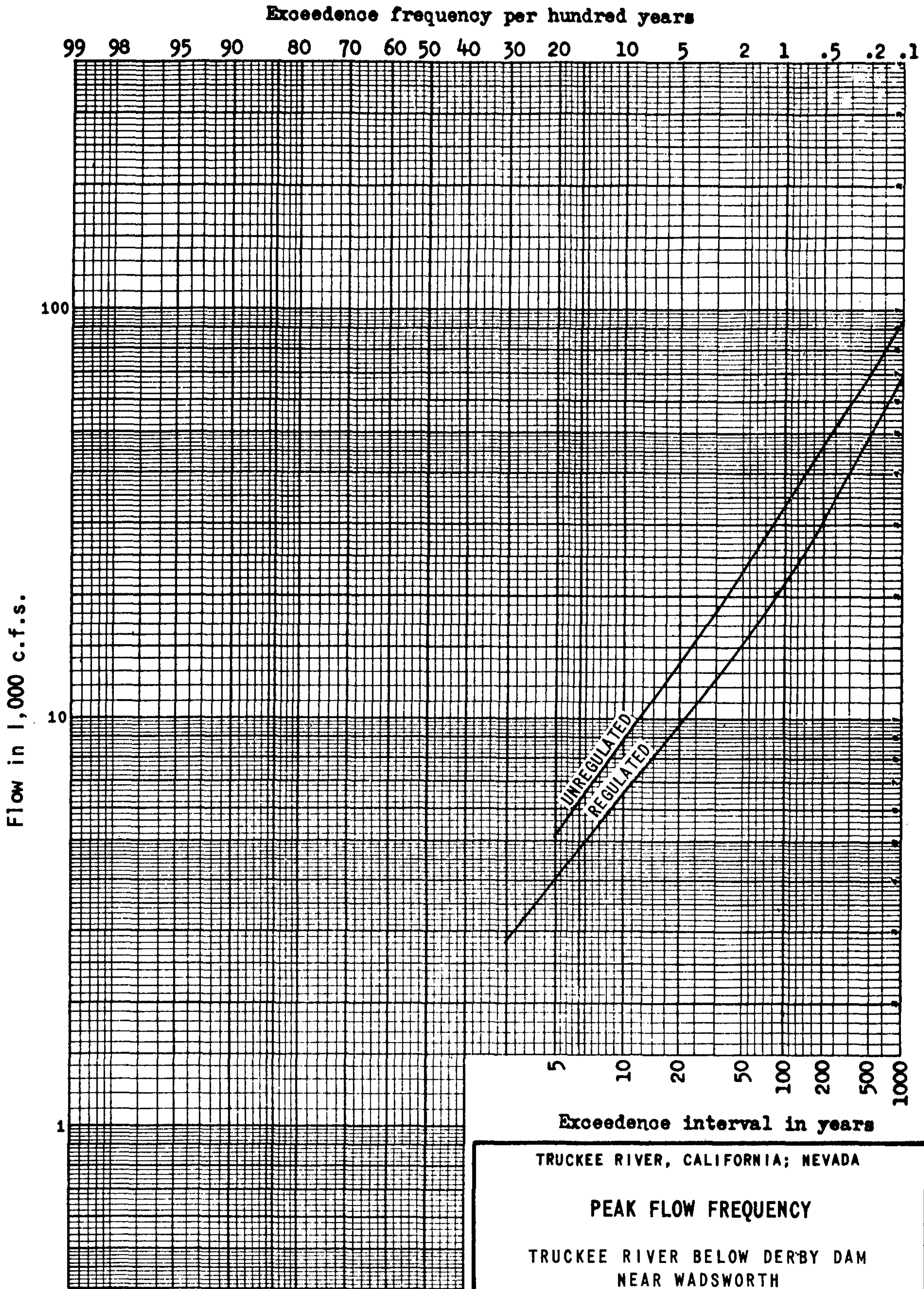
TRUCKEE RIVER, CALIFORNIA; NEVADA

PEAK FLOW FREQUENCY

TRUCKEE RIVER NEAR VISTA
(OCTOBER-MARCH)
USGS NO. 3500

Corps of Engineers, Sacramento, Calif

Prepared: P.W. Date: AUGUST 1982



Total Drainage Area: 1670 sq. mi.

Contributing Drainage Area: 1080 sq. mi.
Below Lake Tahoe and
Washoe Lake

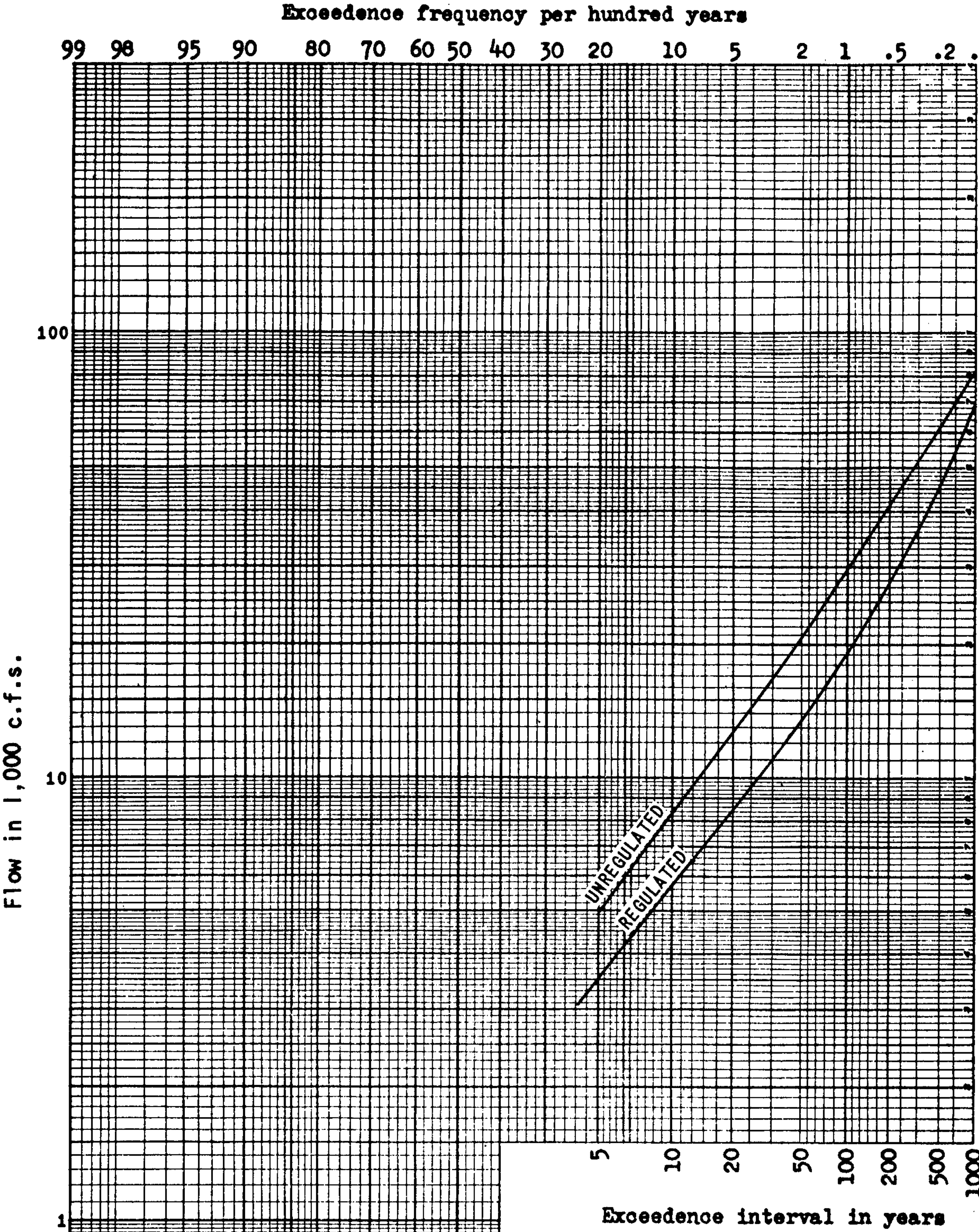
TRUCKEE RIVER, CALIFORNIA; NEVADA

PEAK FLOW FREQUENCY

TRUCKEE RIVER BELOW DERBY DAM
NEAR WADSWORTH
USGS #3516 (October-March)

Corps of Engineers, Sacramento, Calif.

Prepared: J.H. **Date:** NOVEMBER 1979



Total Drainage Area: 1815 sq. mi.

Contributing Drainage Area: 1225 sq. mi.
Below Lake Tahoe and
Washoe Lake

TRUCKEE RIVER, CALIFORNIA; NEVADA

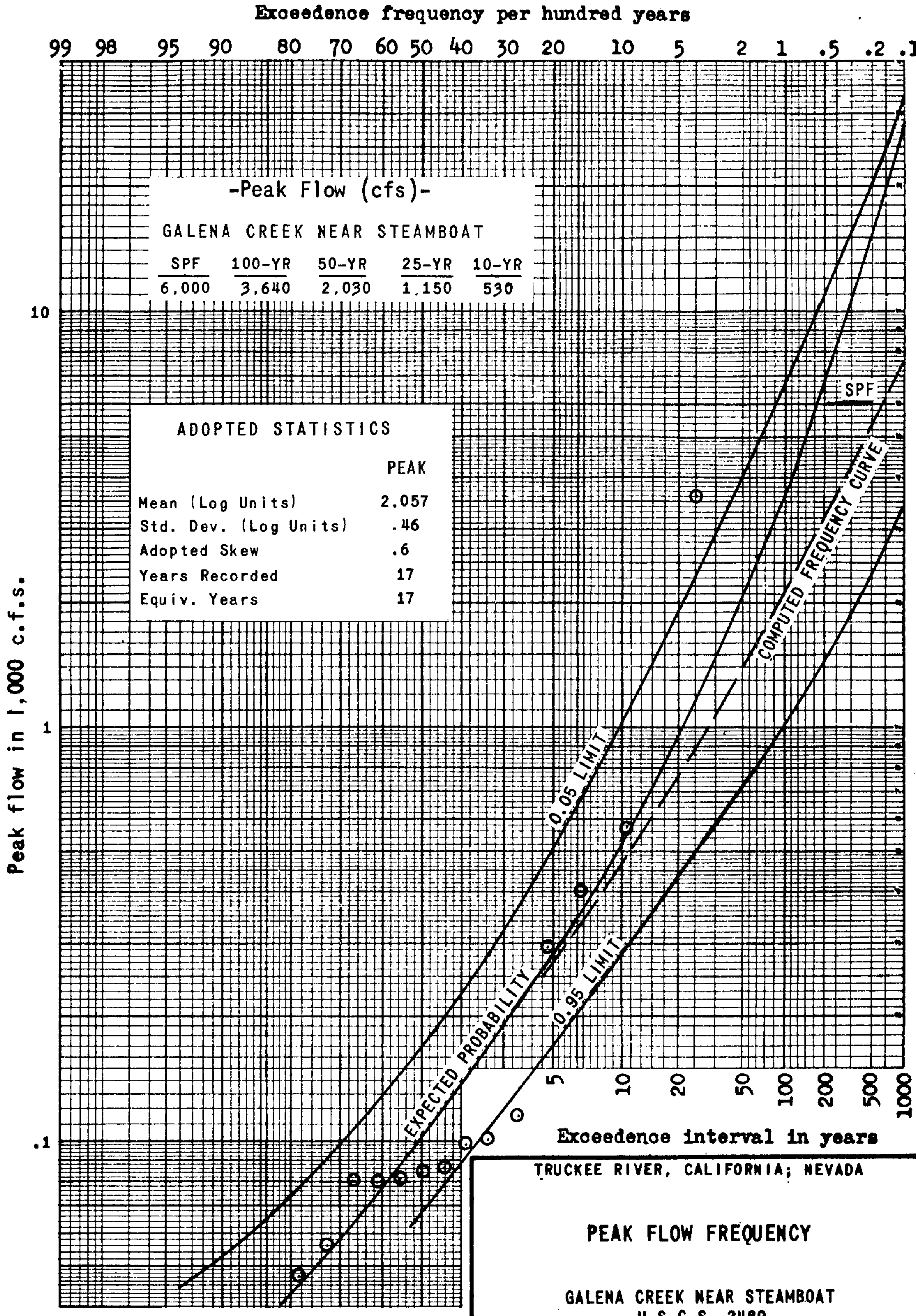
PEAK FLOW FREQUENCY

TRUCKEE RIVER NEAR NIXON
(October-March)
USGS #3517

Corps of Engineers, Sacramento, Calif.

Prepared: J.H. **Date:** NOVEMBER 1979

SHEET 4 OF 4 CHART 21



Period of Record: 1962-1978

Total Drainage Area: 8.5 sq. mi.

TRUCKEE RIVER, CALIFORNIA; NEVADA

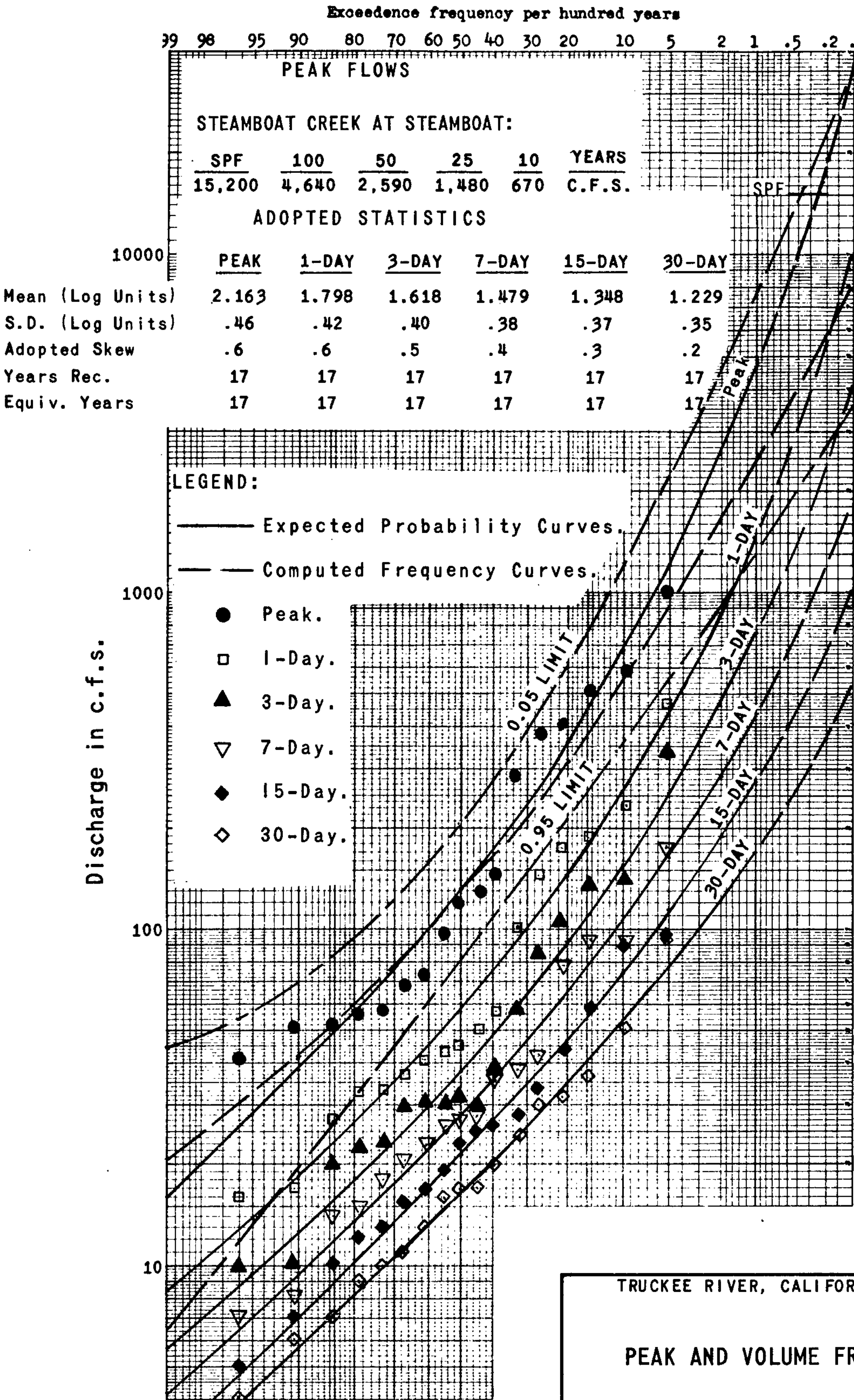
PEAK FLOW FREQUENCY

GALENA CREEK NEAR STEAMBOAT
U.S.G.S. 3489

Corps of Engineers, Sacramento, Calif.

Prepared: J.H. **Date:** NOVEMBER 1979

CHART 22



PEAK FLOWS

STEAMBOAT CREEK AT STEAMBOAT:

SPF	100	50	25	10	YEARS
15,200	4,640	2,590	1,480	670	C.F.S.

ADOPTED STATISTICS

	PEAK	1-DAY	3-DAY	7-DAY	15-DAY	30-DAY
Mean (Log Units)	2.163	1.798	1.618	1.479	1.348	1.229
S.D. (Log Units)	.46	.42	.40	.38	.37	.35
Adopted Skew	.6	.6	.5	.4	.3	.2
Years Rec.	17	17	17	17	17	17
Equiv. Years	17	17	17	17	17	17

Period of Record: 1962-1978

Total Drainage Area: 123.0 sq. mi.

Contributing Drainage Area: 39.3 sq. mi.
Below Washoe Lake

TRUCKEE RIVER, CALIFORNIA; NEVADA

PEAK AND VOLUME FREQUENCIES

STEAMBOAT CREEK AT STEAMBOAT (30)

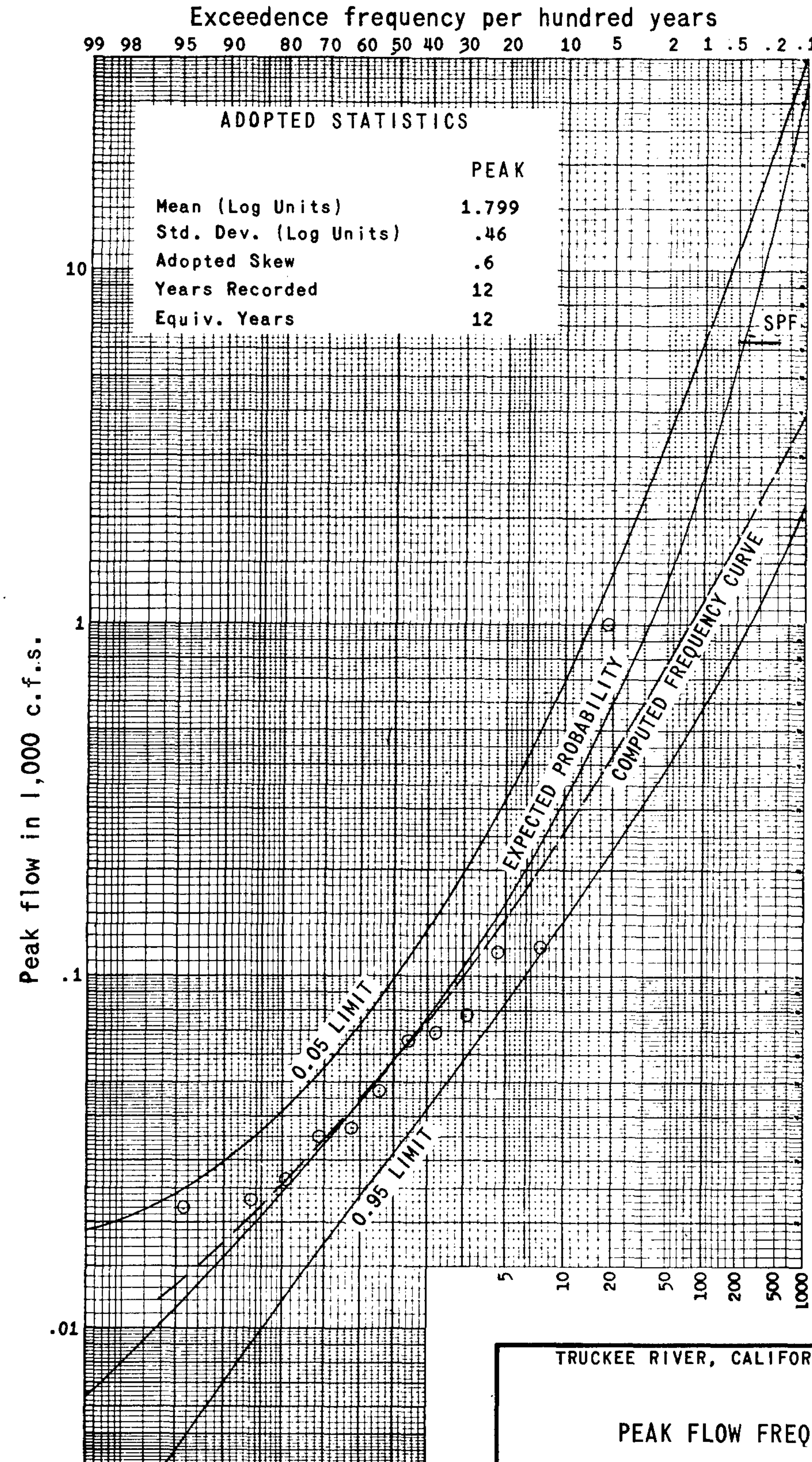
USGS NO. 3493

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: C.A.P.

Date: NOVEMBER 1979

CHART 23



Period of Record: 1962-1971, 1973-1974
Total Drainage Area: 11.5 sq. mi.

TRUCKEE RIVER, CALIFORNIA; NEVADA

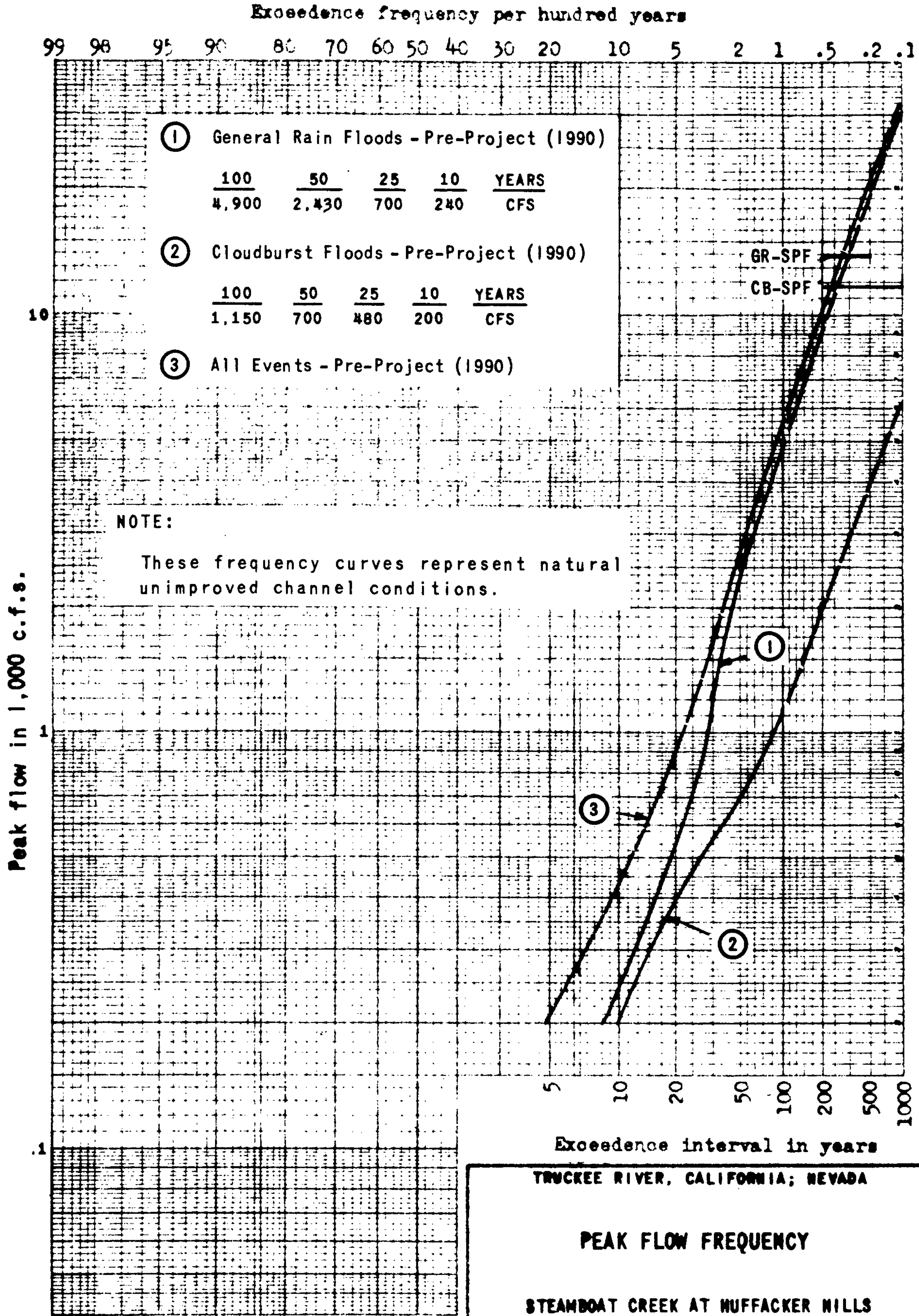
PEAK FLOW FREQUENCY

HUNTER CREEK NEAR RENO
USGS #3476

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.
Date: NOVEMBER 1979

CHART 24



TRUCKEE RIVER, CALIFORNIA; NEVADA

PEAK FLOW FREQUENCY

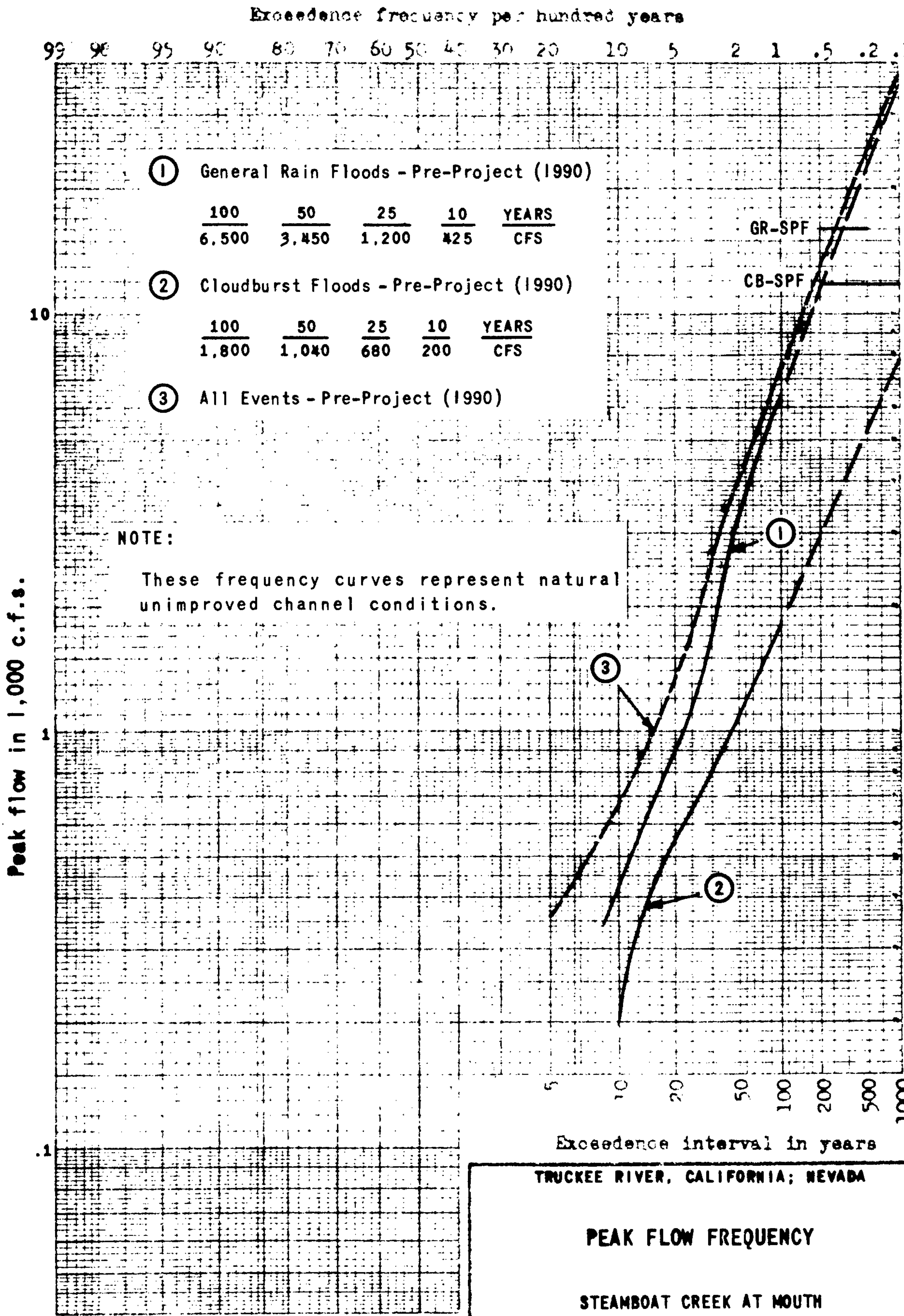
STEAMBOAT CREEK AT HUFFACKER HILLS
(INDEX POINT 60)

Total Drainage Area: 194.0 sq. mi.
Contributing Drainage Area: 110.4 sq. mi.

*Revised March 1983

Corps of Engineers, Sacramento, Calif.

Prepared: P.W. Date: AUGUST 1982



TRUCKEE RIVER, CALIFORNIA; NEVADA

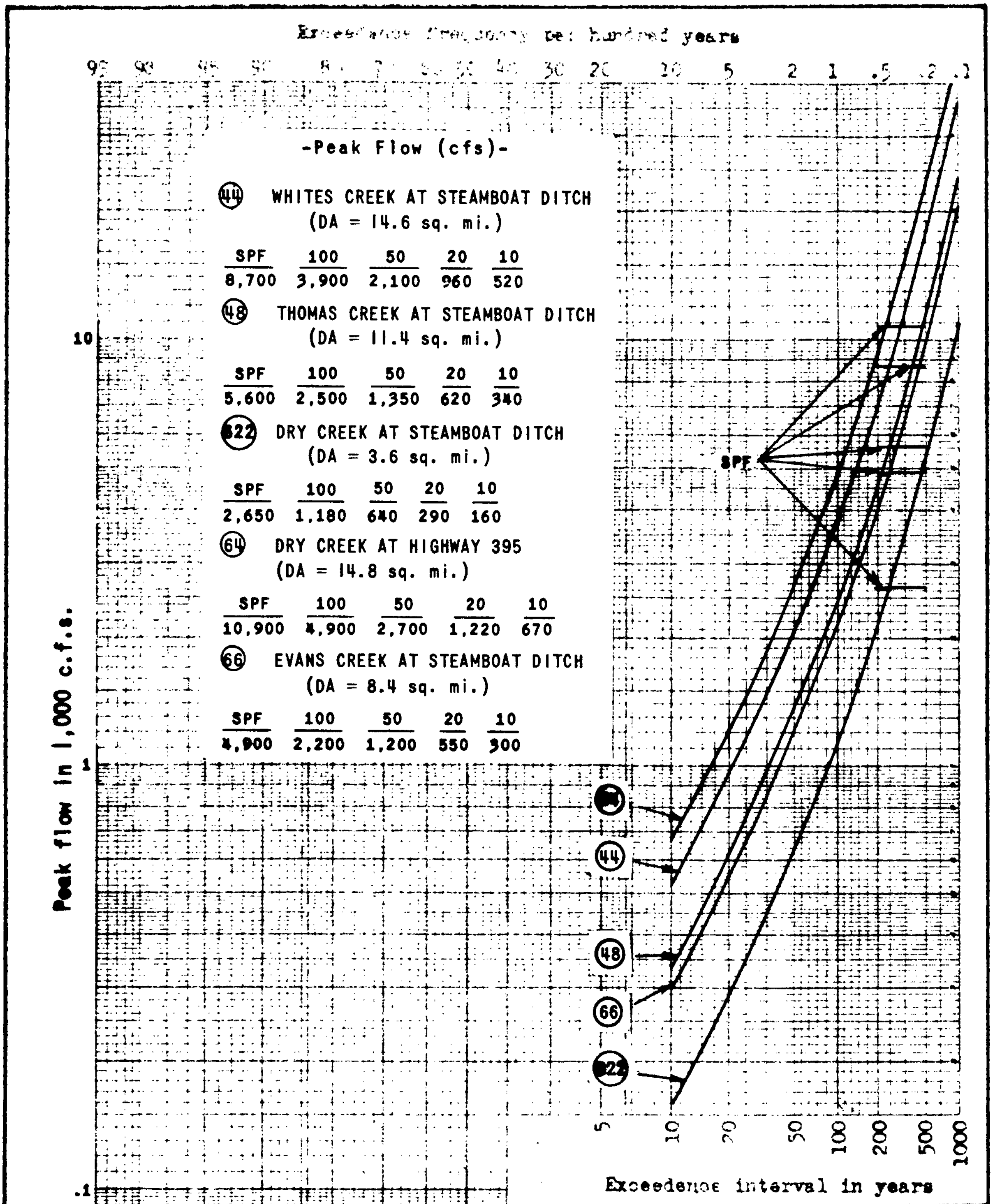
PEAK FLOW FREQUENCY

STEAMBOAT CREEK AT MOUTH
(INDEX POINT 84)

Corps of Engineers, Sacramento, Calif.

*Revised March 1983

Prepared. P.W. Date: AUGUST 1982



TRUCKEE RIVER, CALIFORNIA; NEVADA

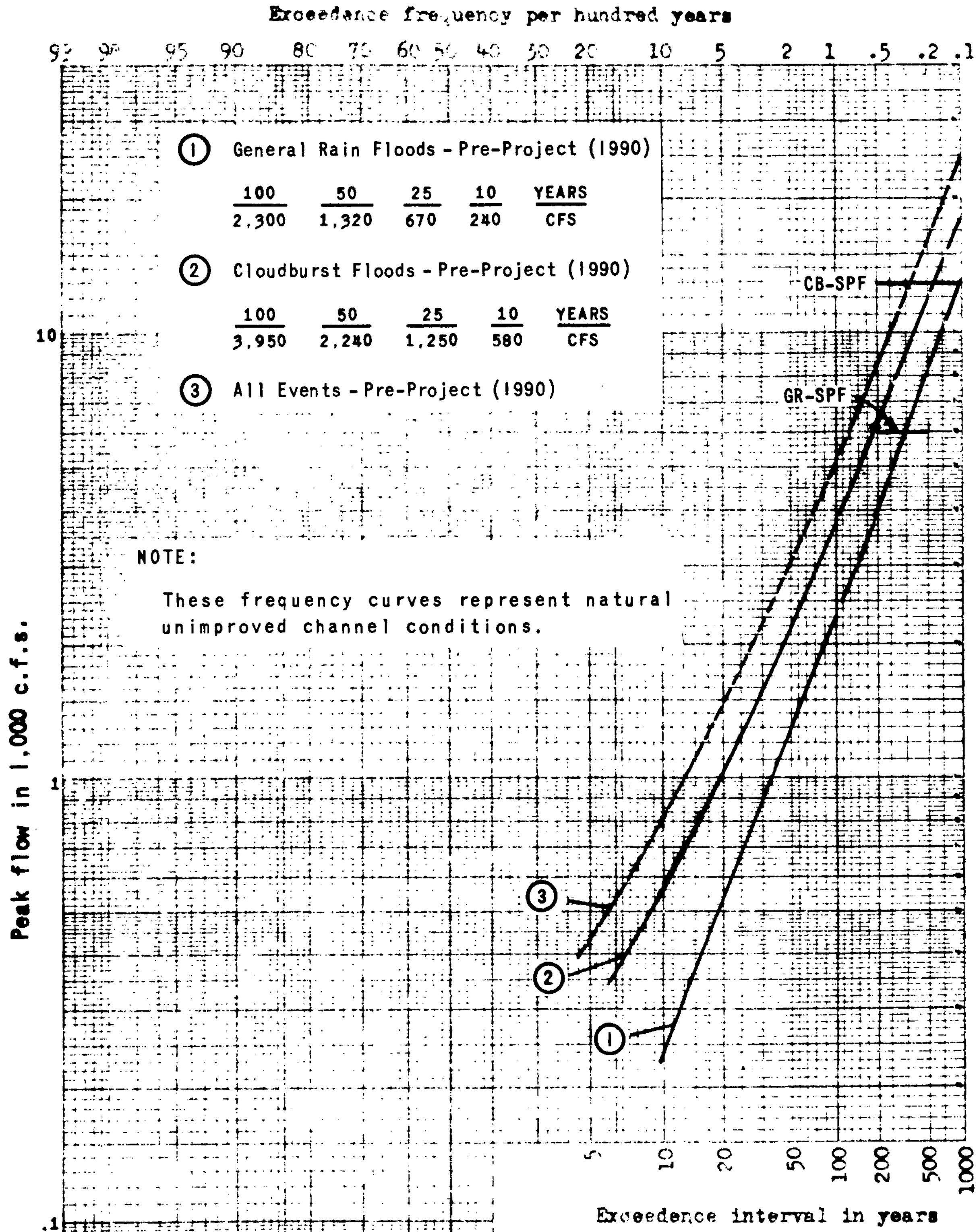
PEAK FLOW FREQUENCY

DRY, EVANS, WHITES, THOMAS CREEKS
AT STEAMBOAT DITCH AND DRY CREEK
AT HIGHWAY 395

Corps of Engineers. Sacramento, Calif.

Prepared: R.C.K. Date: NOVEMBER 1979

CHART 26



Total Drainage Area: 41 sq. mi.

*Revised March 1983

TRUCKEE RIVER, CALIFORNIA; NEVADA

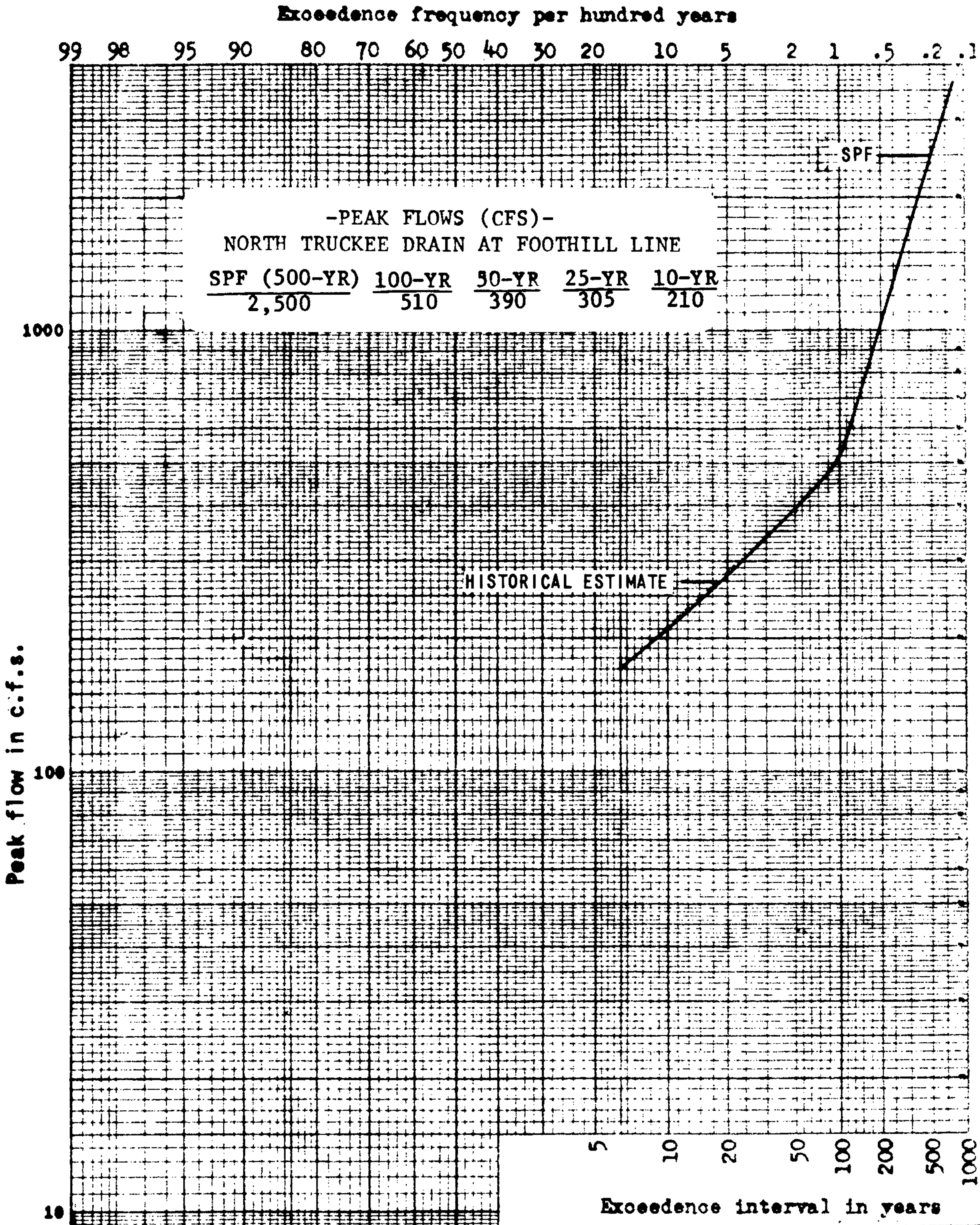
PEAK FLOW FREQUENCY

BOYNTON SLOUGH BELOW DRY CREEK
(INDEX POINT 70)

Corps of Engineers, Sacramento, Calif.

Prepared: P.W. Date: AUGUST 1982

CHART 27



TOTAL D.A.=78.5 sq.mi.

CONTRIBUTING D.A.=56.9 sq.mi.

TRUCKEE RIVER, CALIFORNIA; NEVADA

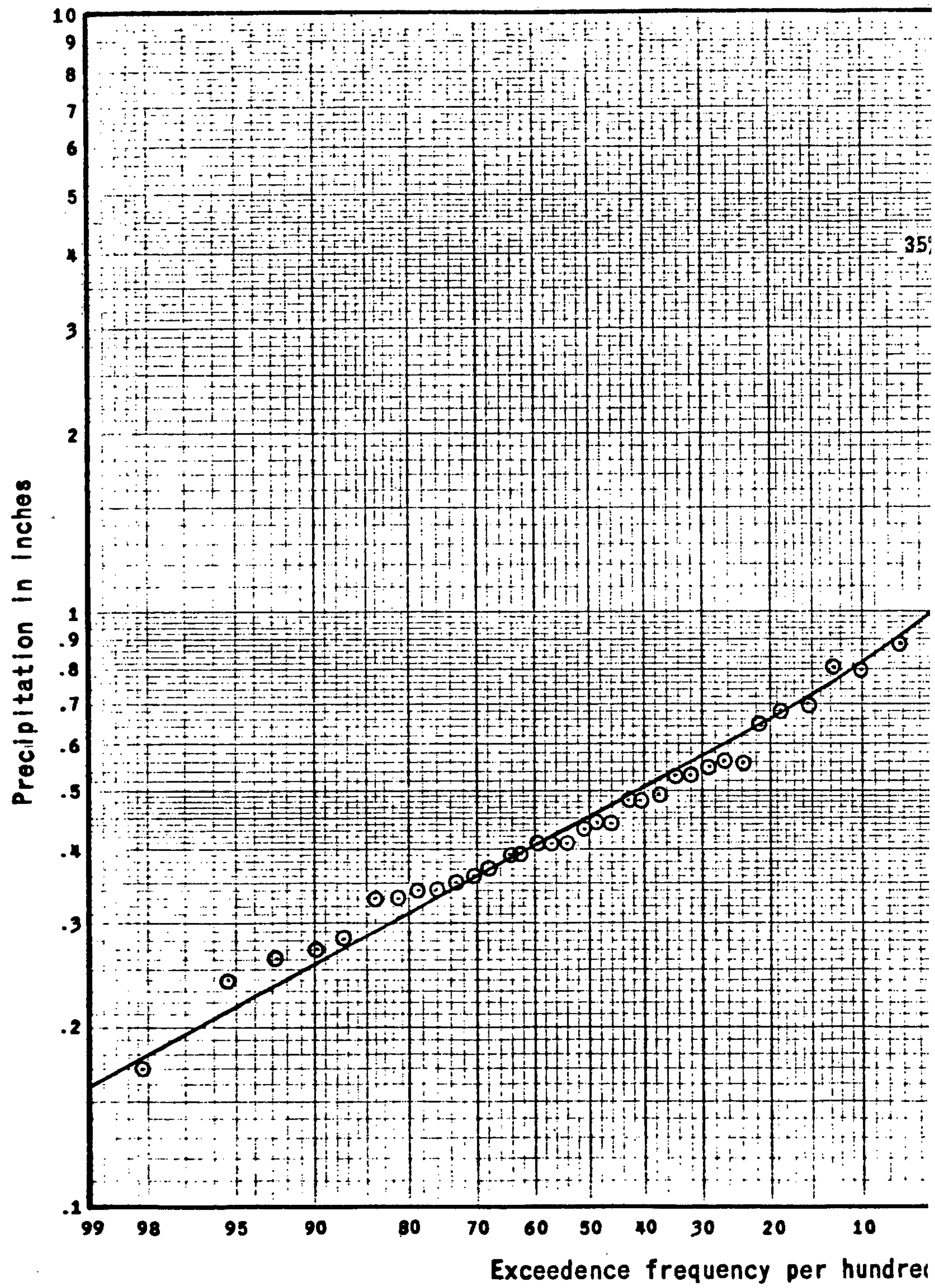
PEAK FLOW FREQUENCY

NORTH TRUCKEE DRAIN AT FOOTHILL LINE

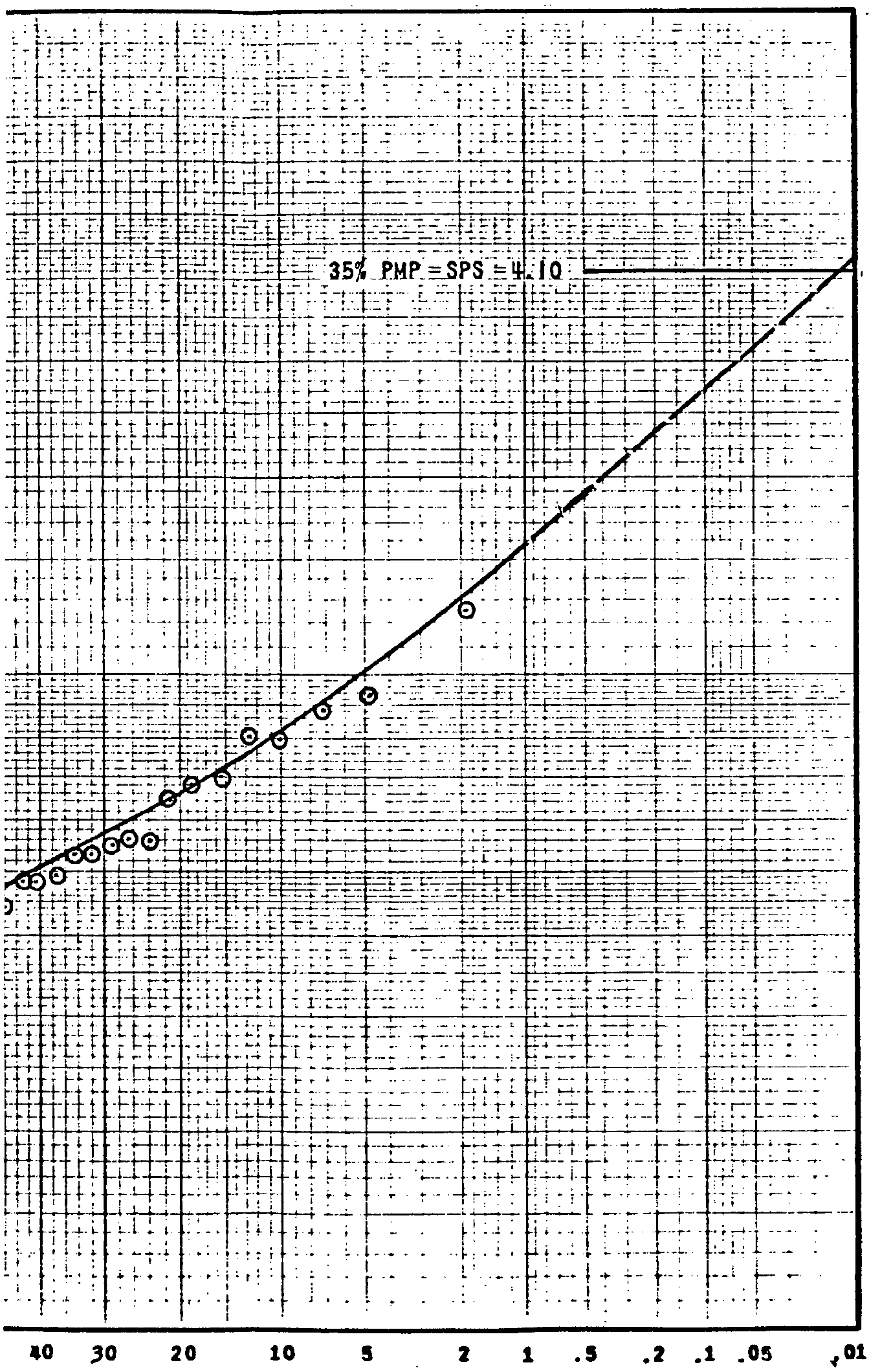
Corps of Engineers, Sacramento, Calif.

Prepared: PW JH Date: NOVEMBER 1979

CHART 28



Precipitation in Inches
10
9
8
7
6
5
4
3
2
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
99
98
95
90
80
70
60
50
40
30
20
10
Exceedence frequency per hundre



:e frequency per hundred years

RECURRENCE INTERVAL IN YEARS	RATIO OF SPS
SPF	1.00
500	.58
200	.46
100	.38
50	.32
25	.26
10	.20

*Revised

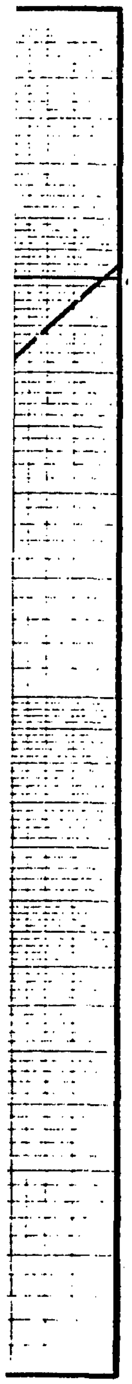
TRUCKEE RIVER, CALIFO

3-HOUR PRECIPITATIO
FOR
RENO NWS-AP, N

CORPS OF ENGINEERS, SACRA

Prepared: P.W.
Drawn: C.A.P.
Date: I

Period of Record: 1940-1975



RECURRENCE INTERVAL IN YEARS	RATIO OF SPS
SPF	1.00
500	.58
200	.46
100	.38
50	.32
25	.26
10	.20

*Revised March 1983

:ord: 1940-1975

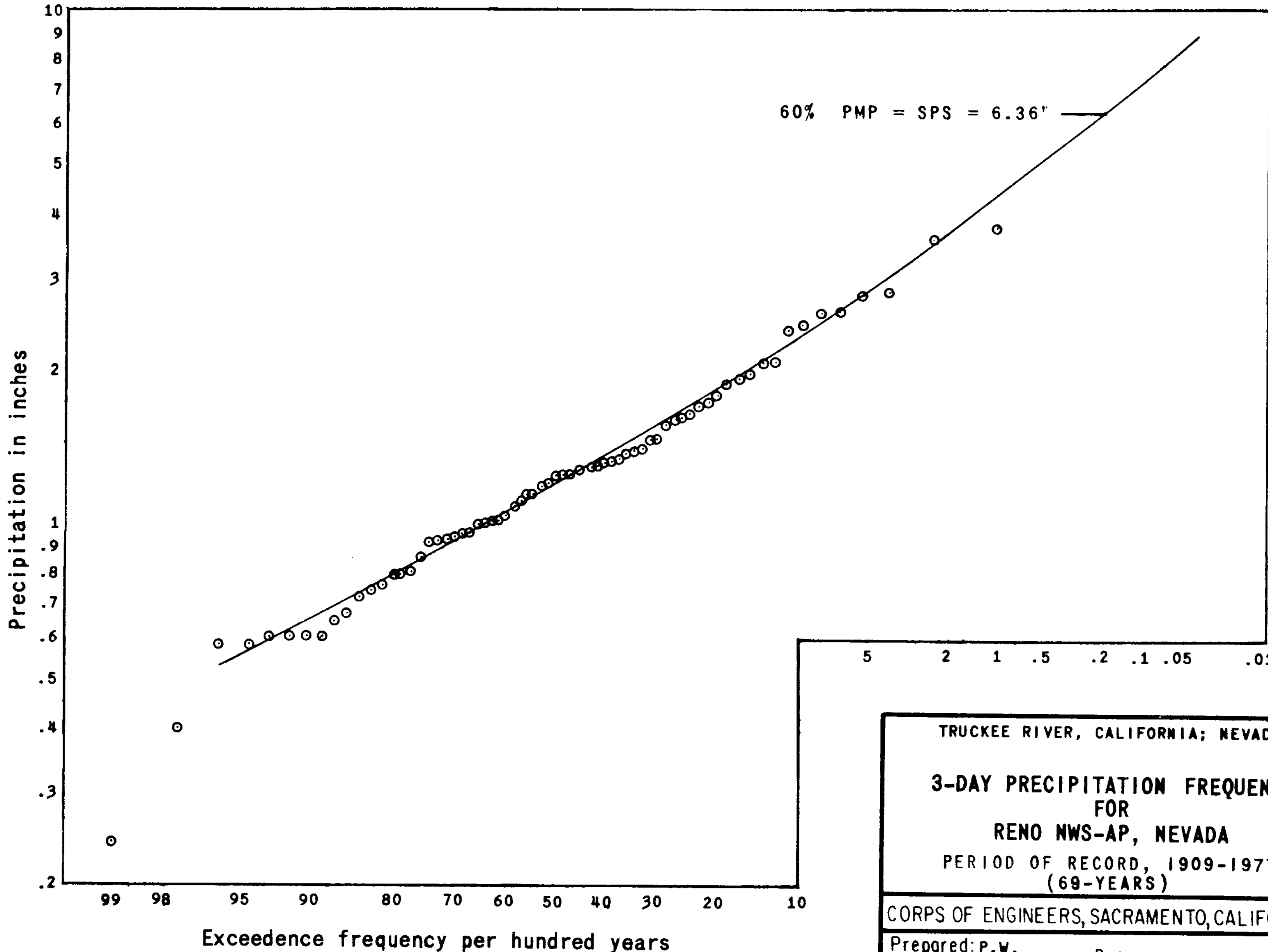
TRUCKEE RIVER, CALIFORNIA; NEVADA

3-HOUR PRECIPITATION FREQUENCY FOR RENO NWS-AP, NEVADA

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: C.A.P.
Date: NOVEMBER 1979

3



TRUCKEE RIVER, CALIFORNIA; NEVADA

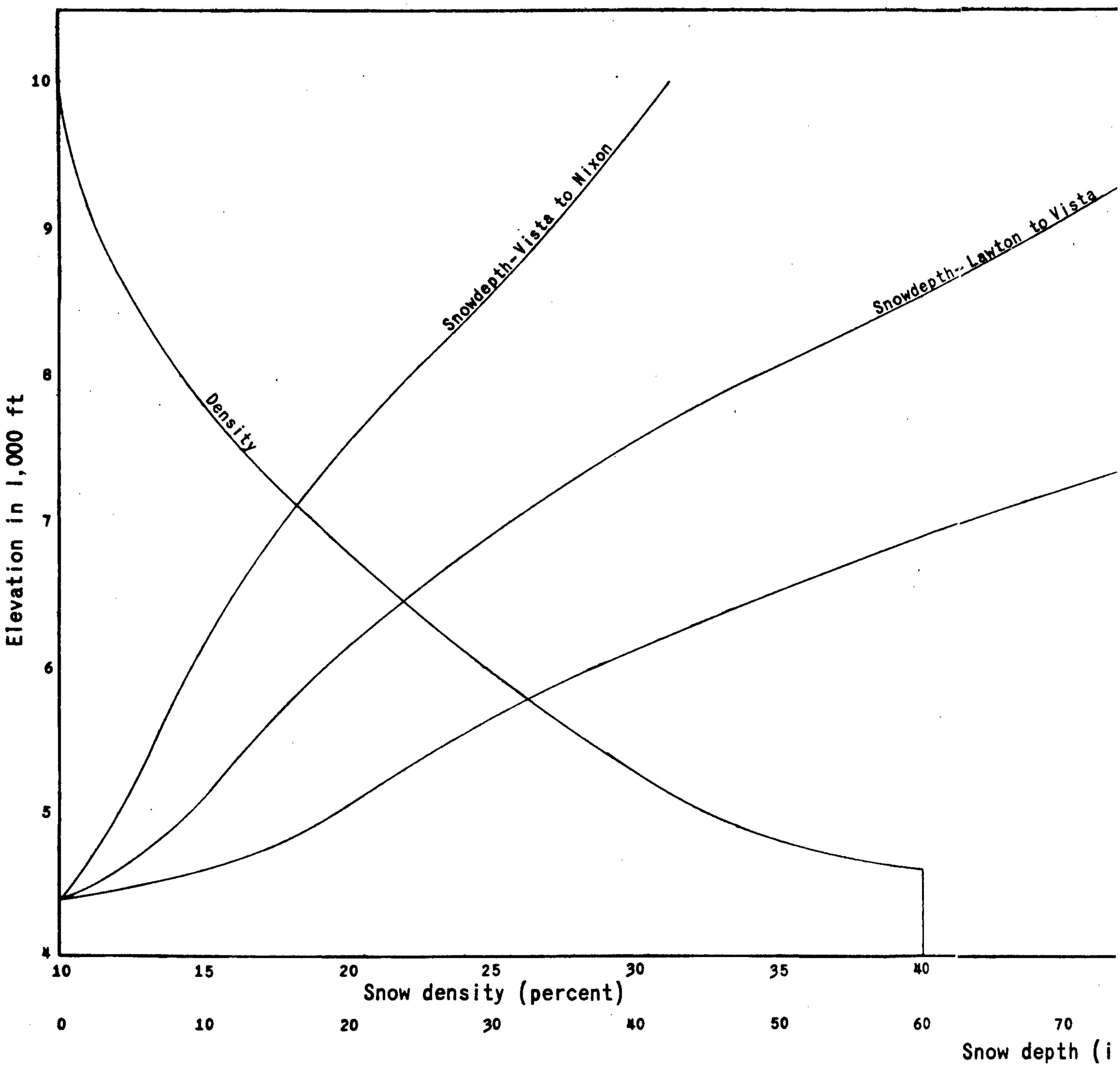
3-DAY PRECIPITATION FREQUENCY FOR RENO NWS-AP, NEVADA

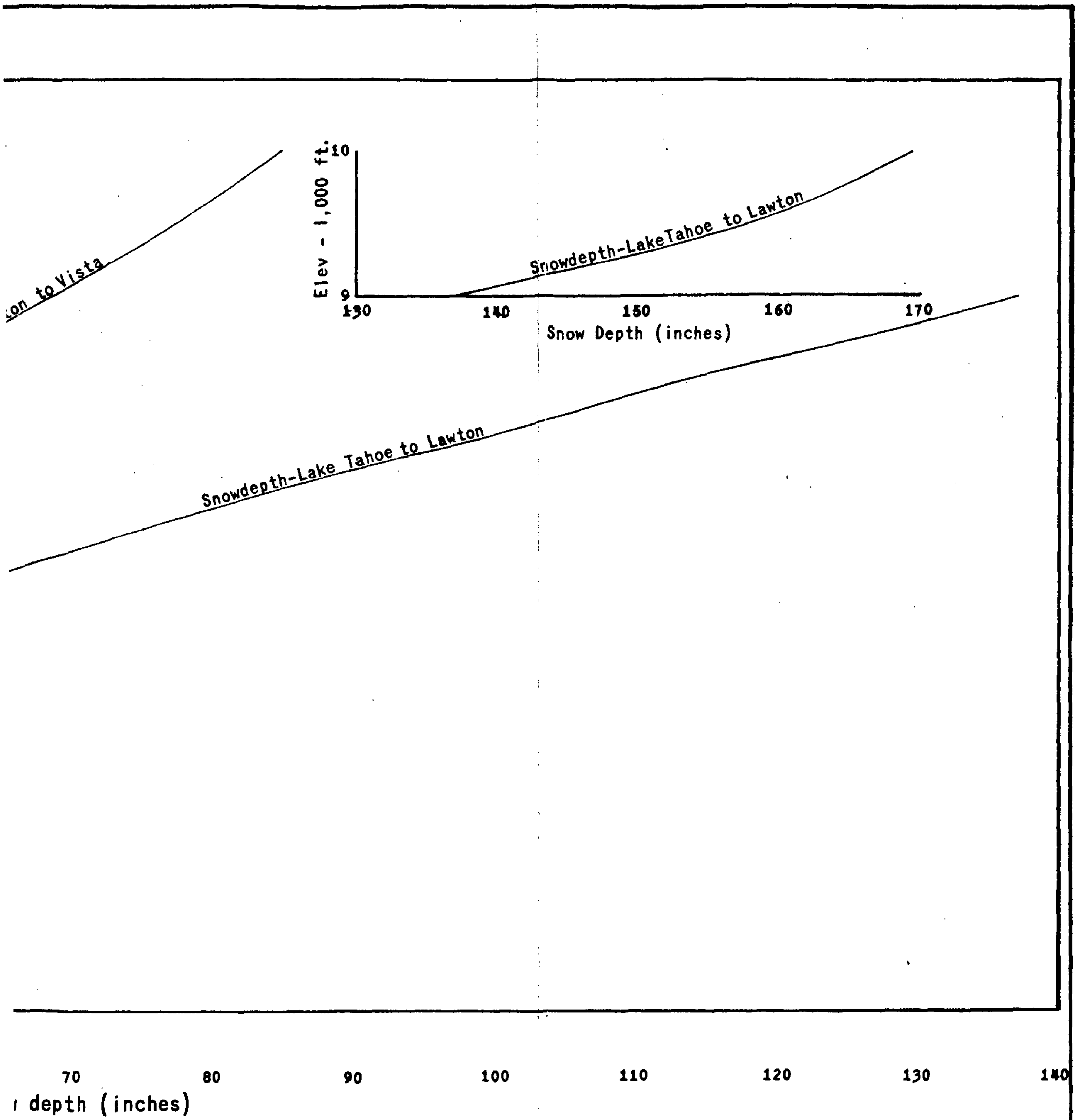
PERIOD OF RECORD, 1909-1977 (69-YEARS)

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: J.H.

Date: NOVEMBER 1979


Elevation in 1,000 ft
10
9
8
7
6
5
4
Snowdepth-Vista to Nixon
Snowdepth-- Lawton to Vista
Density
10
15
20
25
30
35
40
Snow density (percent)
0
10
20
30
40
50
60
70
Snow depth (i



TRUCKEE RIVER, CALIFORNIA; NEVADA

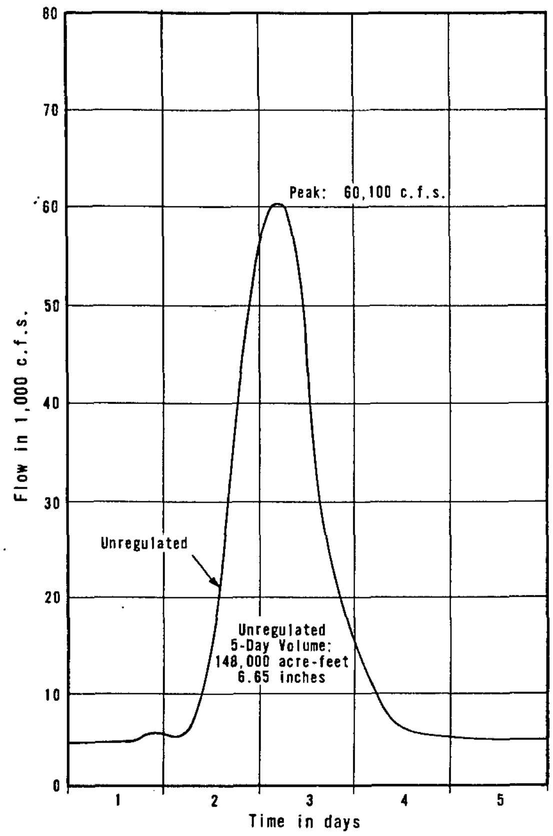
SNOW DEPTHS AND DENSITIES PRIOR TO STANDARD PROJECT STORM

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

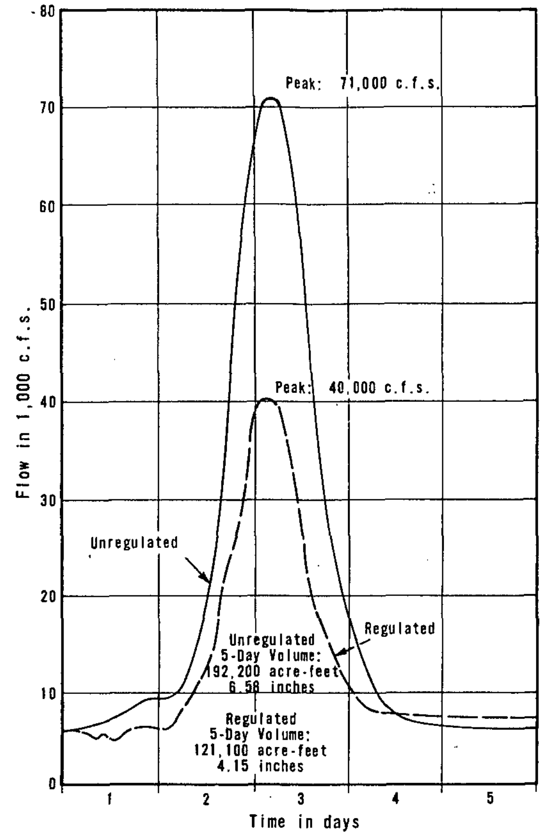
Prepared: R.C.K.
Drawn: J.H.

Date: NOVEMBER 1979

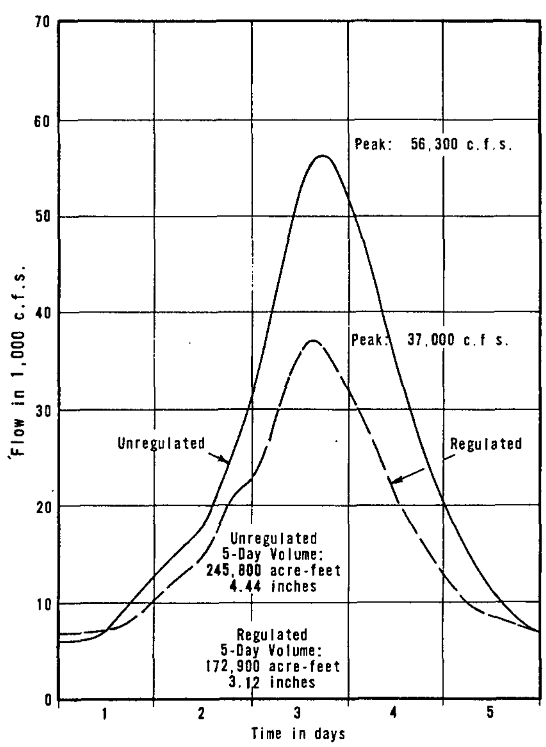
CHART 31



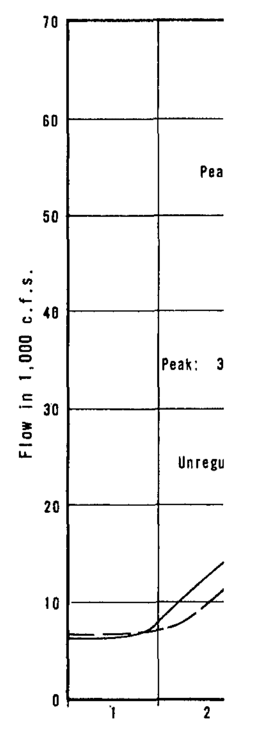
TRUCKEE RIVER AT FARAD, CALIFORNIA
Contributing Drainage Area: 417.5 Sq.Mi.
Index Point - 3460



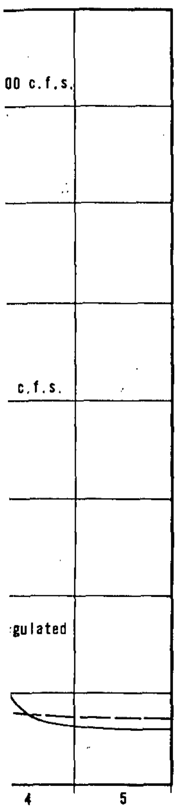
TRUCKEE RIVER AT RENO, NEVADA
Contributing Drainage Area: 548.0 Sq.Mi.
Index Point - 600



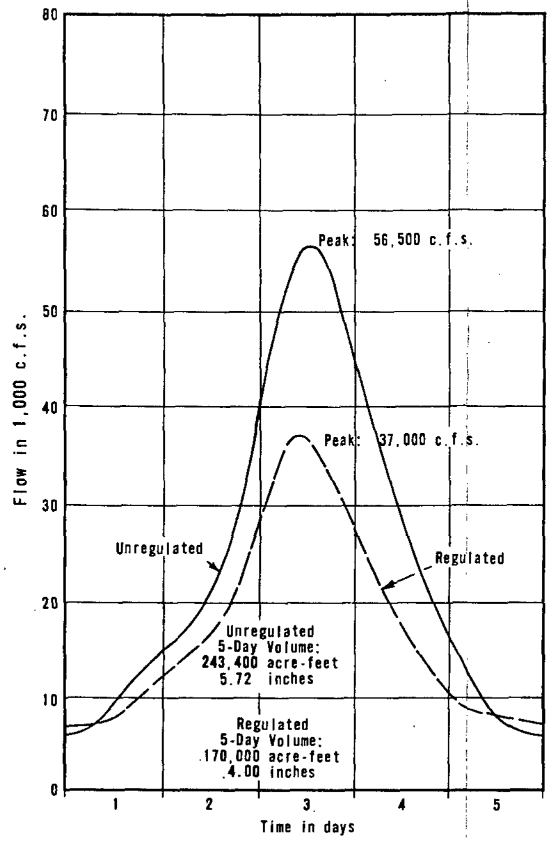
TRUCKEE RIVER BELOW DERBY DAM
NEAR WADSWORTH, NEVADA
Contributing Drainage Area: 1,039 Sq. Mi.
Index Point-720



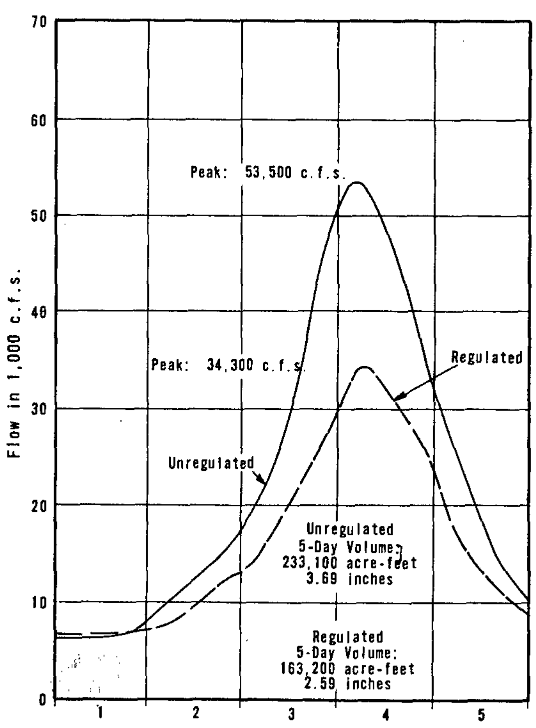
TRUCKEE
Contributing



NEVADA
18.0 Sq.Mi.



TRUCKEE RIVER AT VISTA, NEVADA
Contributing Drainage Area: 798.0 Sq. Mi.
Index Point-700



TRUCKEE RIVER NEAR NIXON, NEVADA
Contributing Drainage Area: 1,184.0 Sq. Mi.
Index Point-740

NOTES:

1. Hydrographs and Peak Flows shown for Index Points 700, 720 and 740 are representative of future land use conditions–year 1990.
2. Contributing drainage area does not include areas above Lake Tahoe and above Washoe Lake, non-contributing area in Spanish Springs Valley, and areas above 9000' elevation.

TRUCKEE RIVER, CALIFORNIA; NEVADA

STANDARD PROJECT FLOOD HYDROGRAPHS

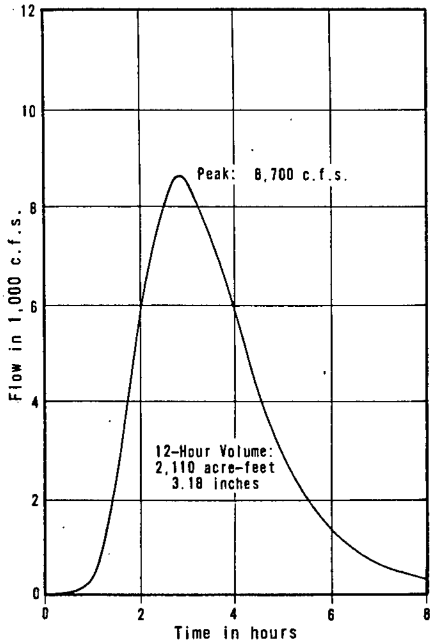
TRUCKEE RIVER

CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA

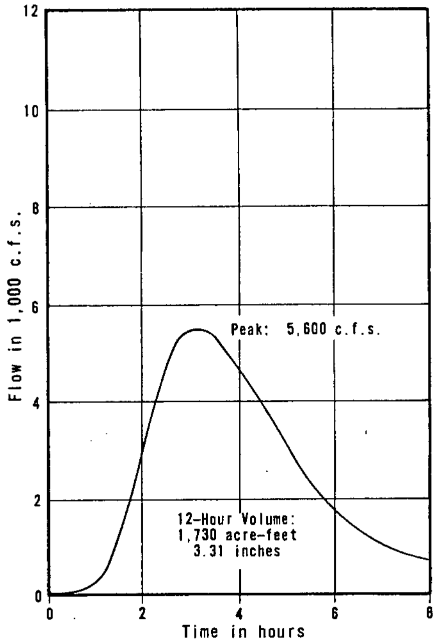
Prepared: P.W.
Drawn: C.A.P.

Date: NOVEMBER 1979

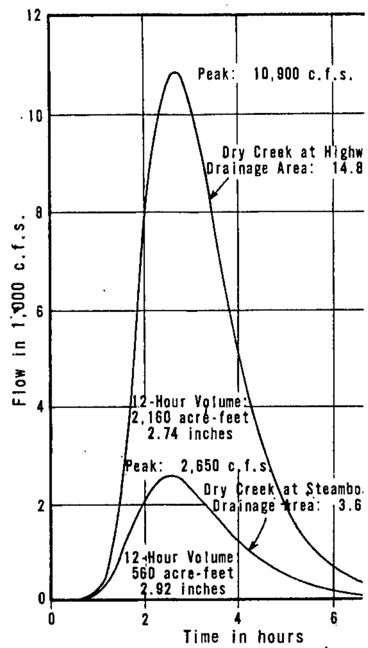
CHART 32



WHITES CREEK AT STEAMBOAT DITCH, NEVADA
Contributing Drainage Area: 14.6 Sq. Mi.
Index Point-44

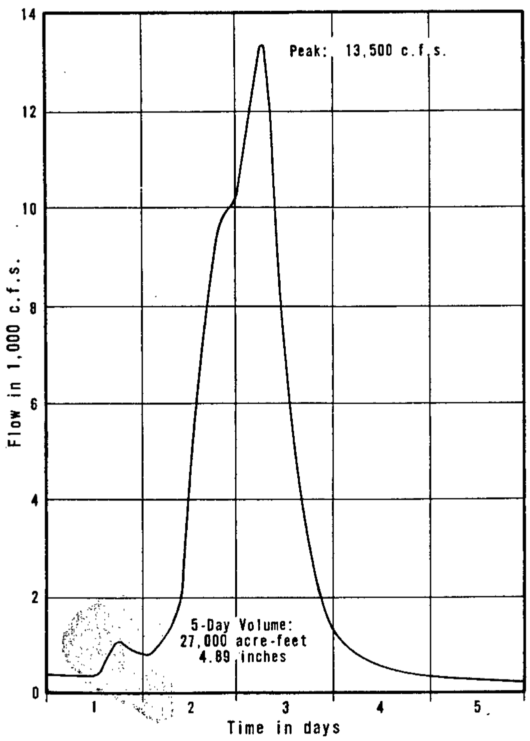


THOMAS CREEK AT STEAMBOAT DITCH, NEVADA
Contributing Drainage Area: 11.4 Sq. Mi.
Index Point-48

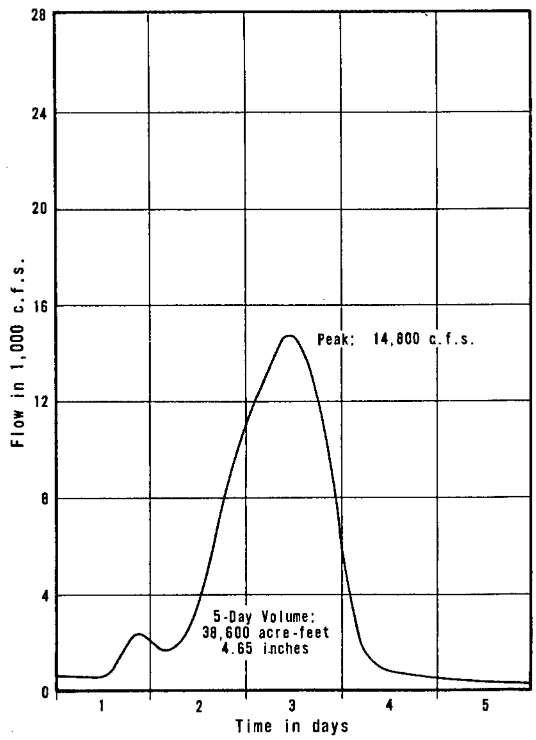


DRY CREEK, NEVADA

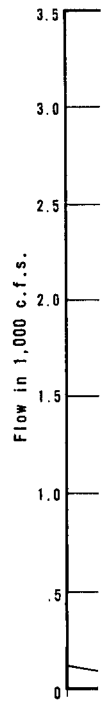
CLOUDBURST FLOO



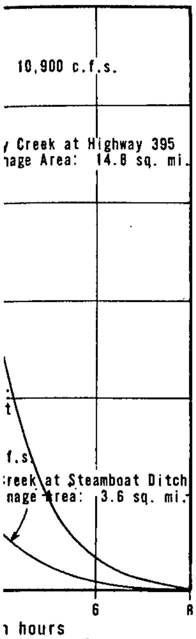
STEAMBOAT CREEK AT HUFFACKER HILLS, NEVADA
PROPOSED DAM SITE
Contributing Drainage Area: 103.9 Sq. Mi.
Index Point-60



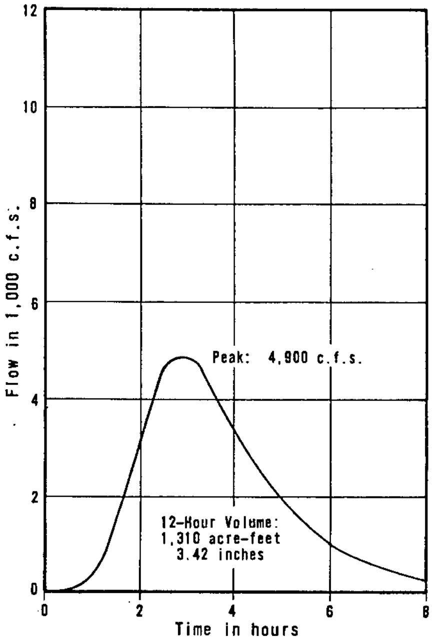
STEAMBOAT CREEK AT MOUTH
Contributing Drainage Area: 155.8 Sq. Mi.
Index Point-84



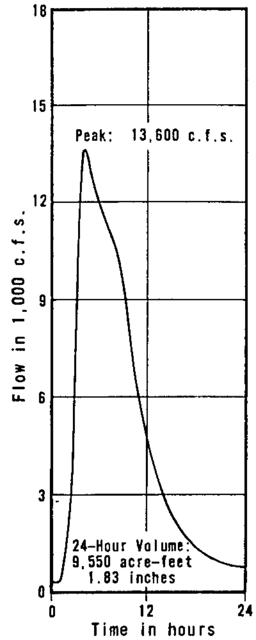
GENERAL RAIN FLOOD HYDROGRAPHS



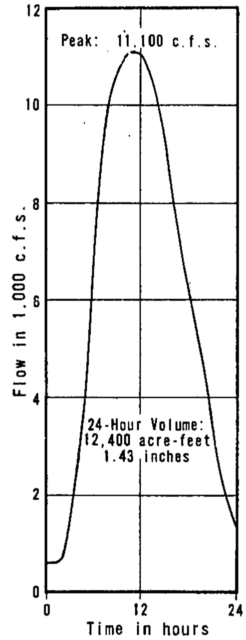
K, NEVADA



EVANS CREEK AT STEAMBOAT DITCH, NEVADA
Contributing Drainage Area: 8.4 Sq. Mi.
Index Point-66

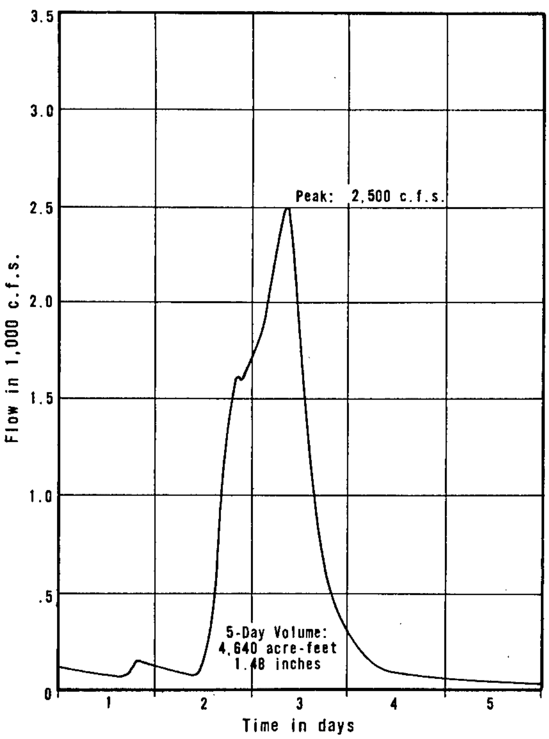


STEAMBOAT CREEK AT HUFFACKER HILLS, NEVADA - PROPOSED DAM SITE
Contributing Drainage Area: 110.4 Sq. Mi.
Index Point-60

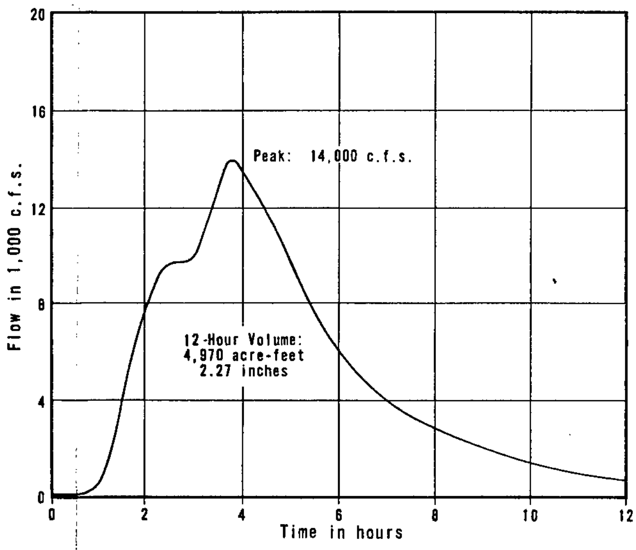


STEAMBOAT CREEK AT MOUTH
Contributing Drainage Area: 162.3 Sq. Mi.
Index Point-84

ST FLOOD HYDROGRAPHS



NORTH TRUCKEE DRAIN AT FOOTHILL LINE
Contributing Drainage Area: 58.9 Sq. Mi.
Index Point-620



BOYNTON SLOUGH BELOW DRY CREEK
Total Drainage Area: 41 sq. mi.
Index Point 70

CLOUDBURST FLOOD HYDROGRAPH

S

NOTE:

Hydrographs represent runoff for future (1990) land use conditions.

TRUCKEE RIVER, CALIFORNIA; NEVADA

STANDARD PROJECT FLOOD HYDROGRAPHS

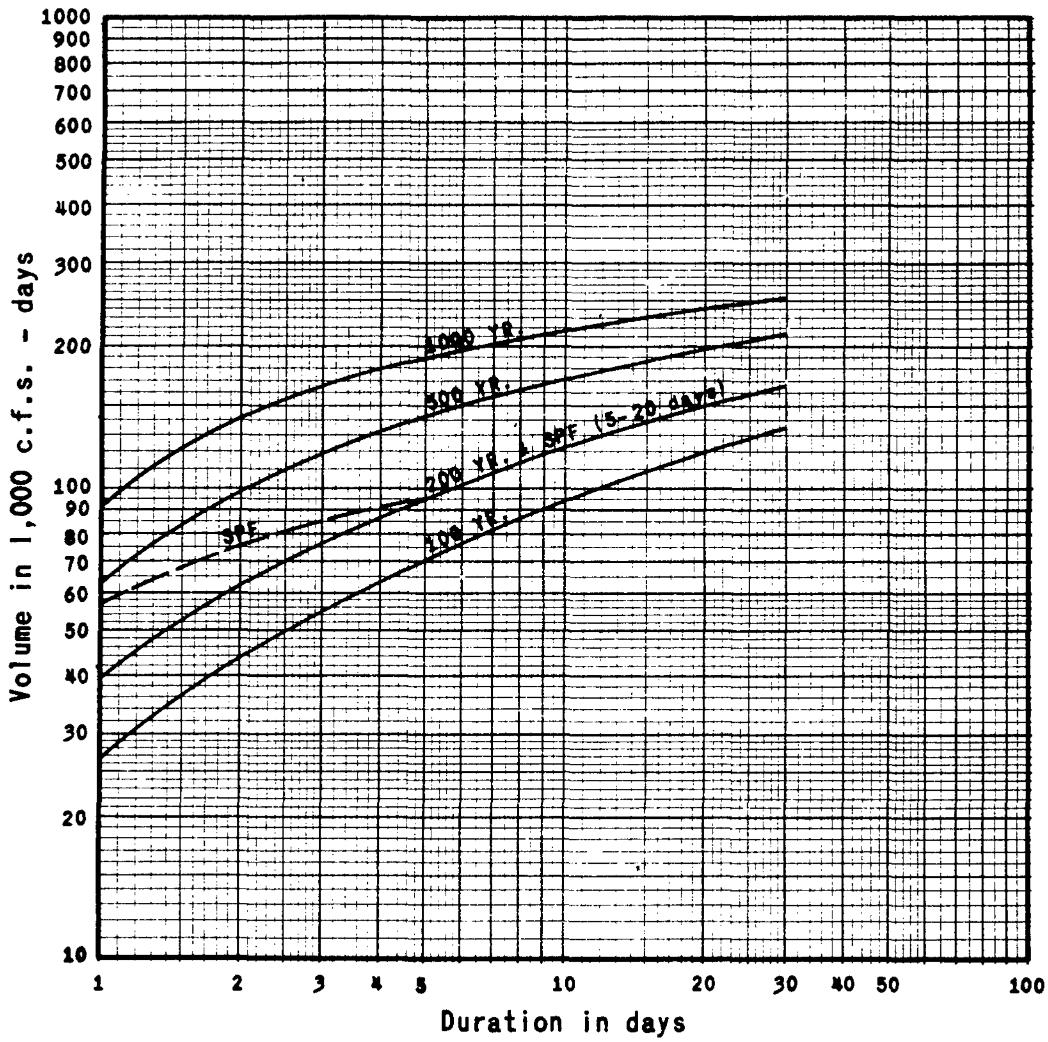
TRUCKEE MEADOWS AND NORTH TRUCKEE DRAIN

CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: C.A.P.

Date: NOVEMBER 1979

CHART 33



TRUCKEE RIVER, CALIFORNIA;NEVADA

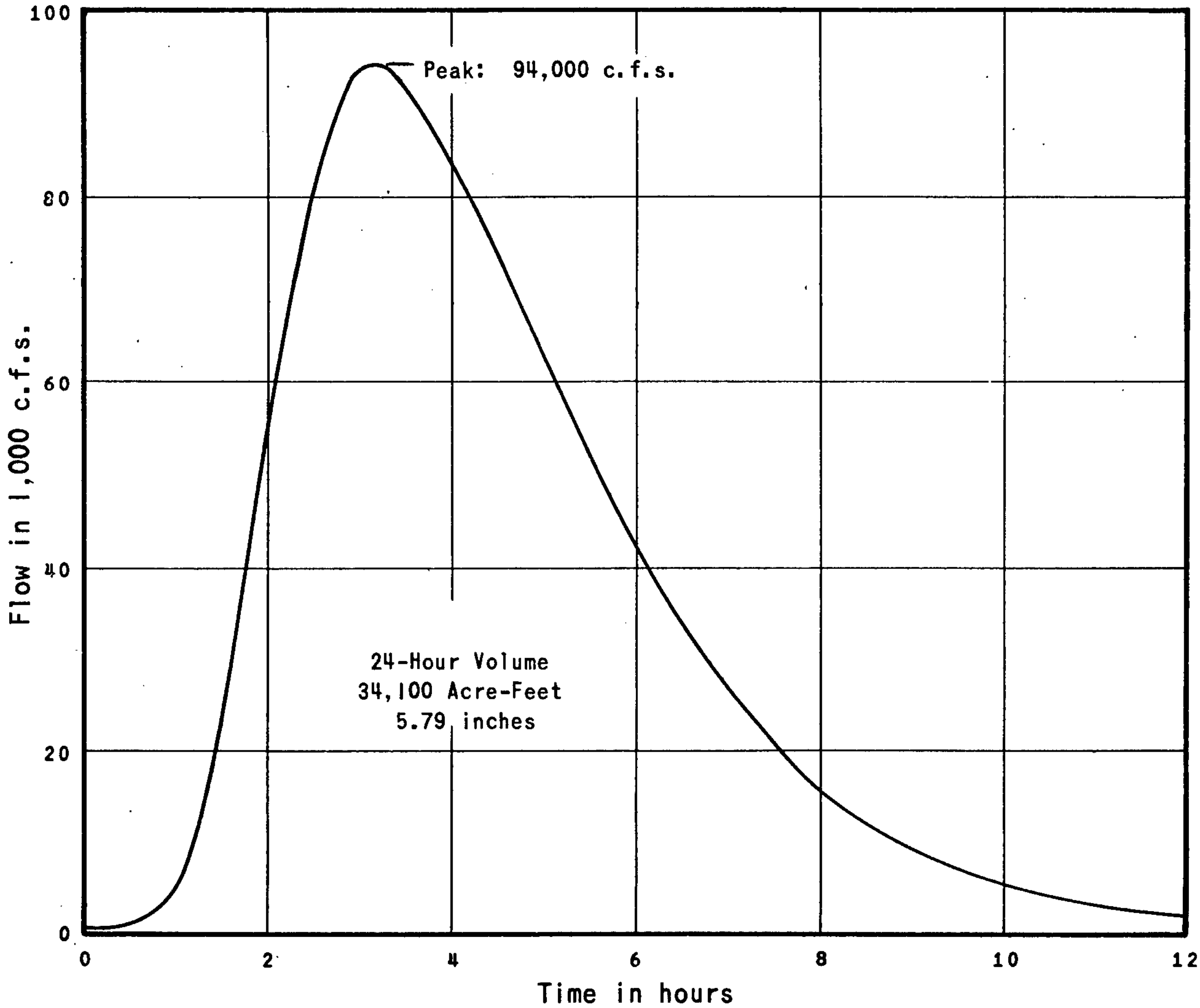
VOLUME-DURATION CURVES

TRUCKEE RIVER AT RENO

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

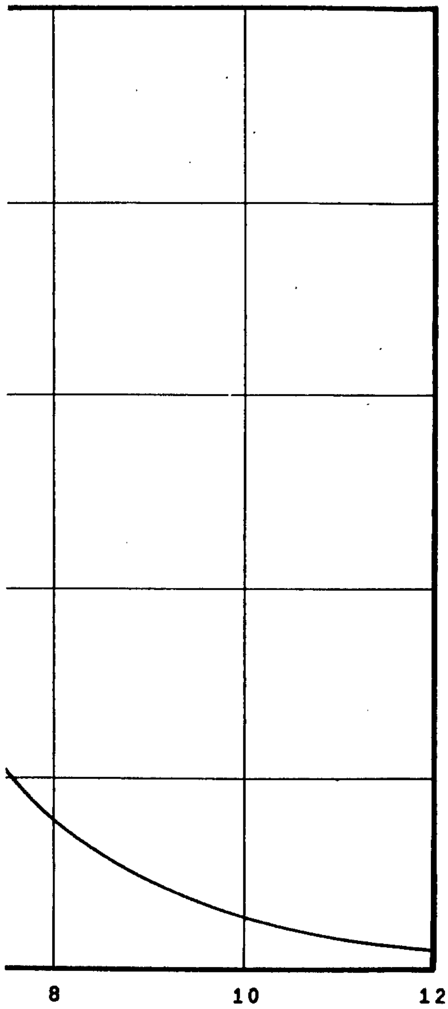
Prepared: R.C.K.
Drawn: C.A.P.
Date: NOVEMBER 1979

GPO587-061/01

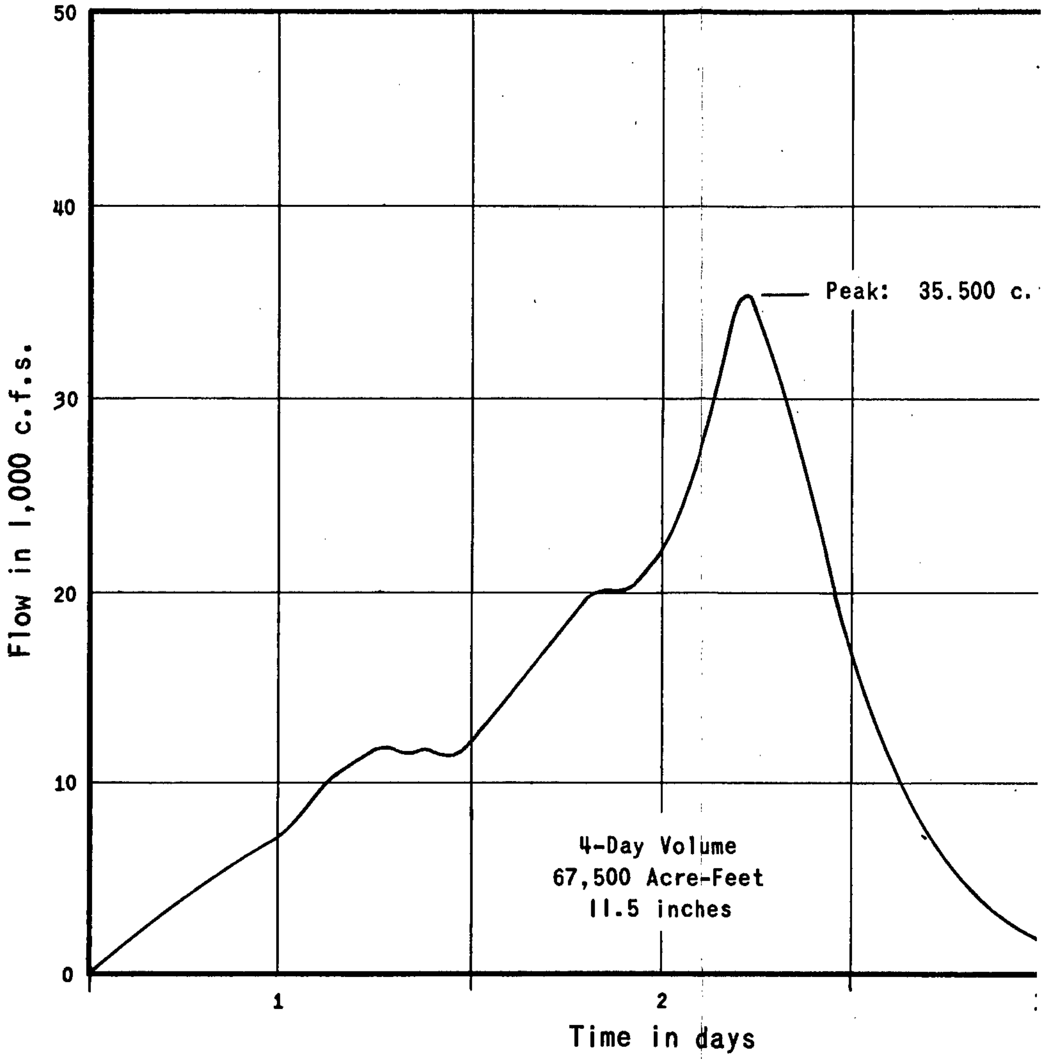


CLOUDBURST

Contributing Drainage Area: 110.4 sq.mi.



0.4 sq.mi.



GENERAL RAIN

Contributing Drainage Area: 110.4 sq. mi.

Revised July 1980

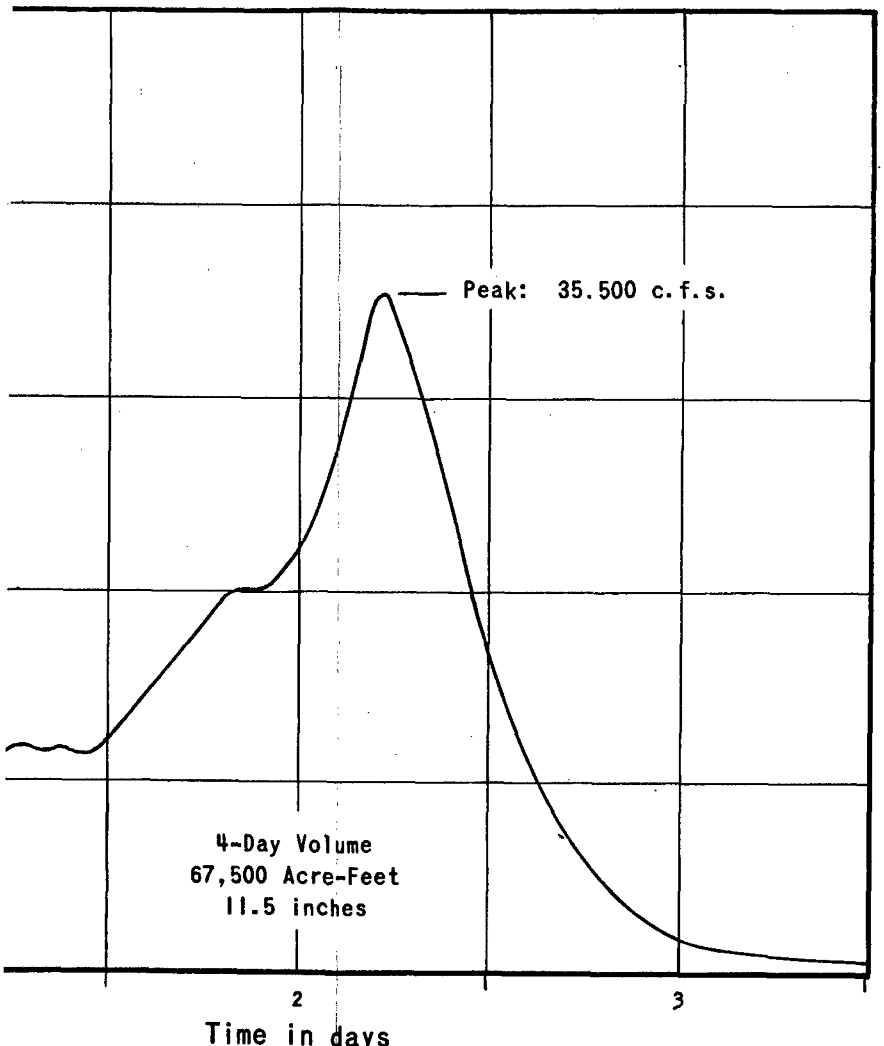
TRUCKEE RI

PRO
FLOO

Ste
Propos
Dam Sit

CORPS OF ENGIN

Prepared: P.W.
Drawn: C.A.P.



GENERAL RAIN

Contributing Drainage Area: 110.4 sq. mi.

Revised July 1980

TRUCKEE RIVER, CALIFORNIA; NEVADA

PROBABLE MAXIMUM FLOOD HYDROGRAPHS

Steamboat Creek at
Proposed Huffacker Hills
Dam Site (index point 60)

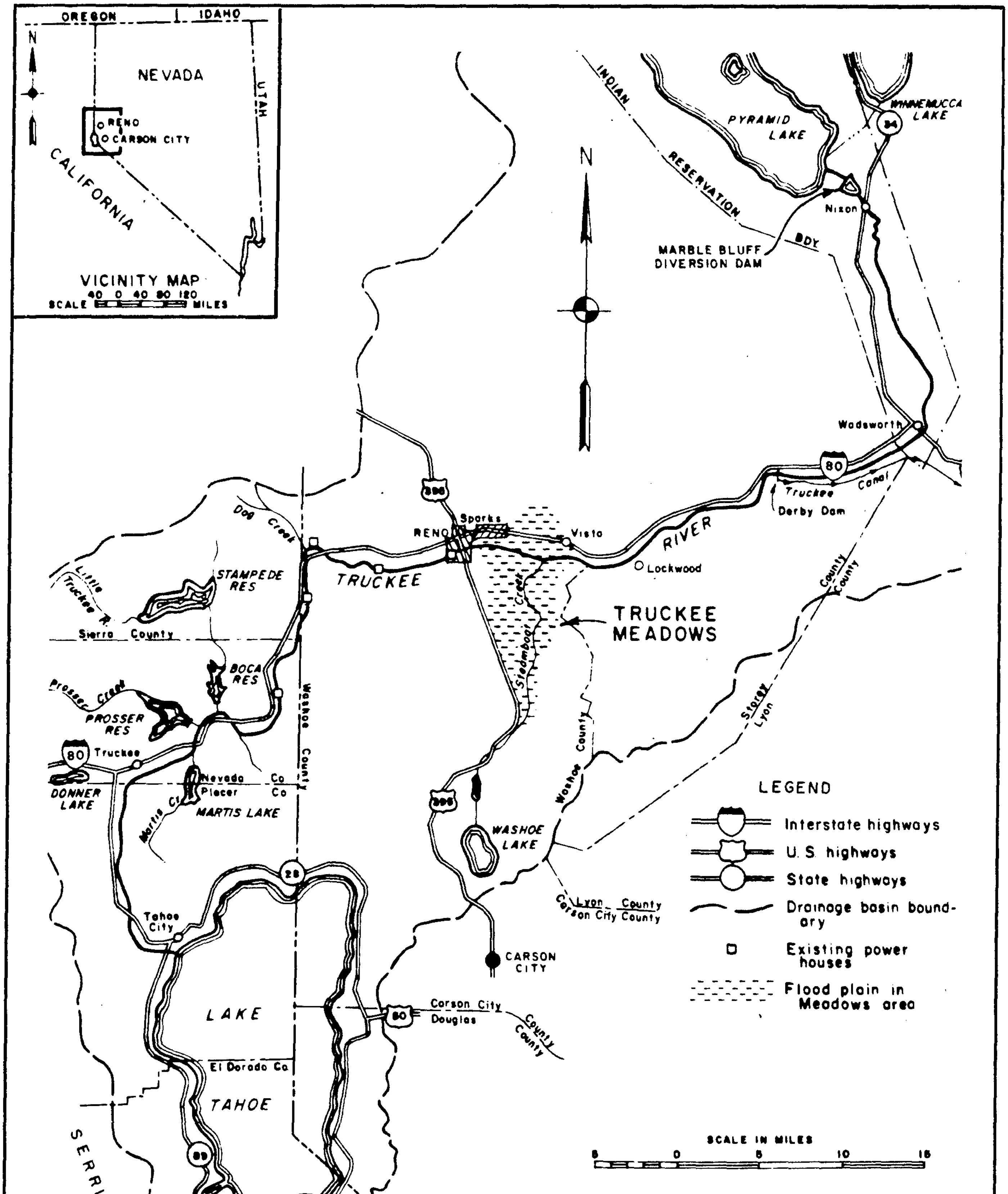
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W.
Drawn: C.A.P.
Date: NOVEMBER 1979

CHART 35

Section B

Hydraulic Analysis

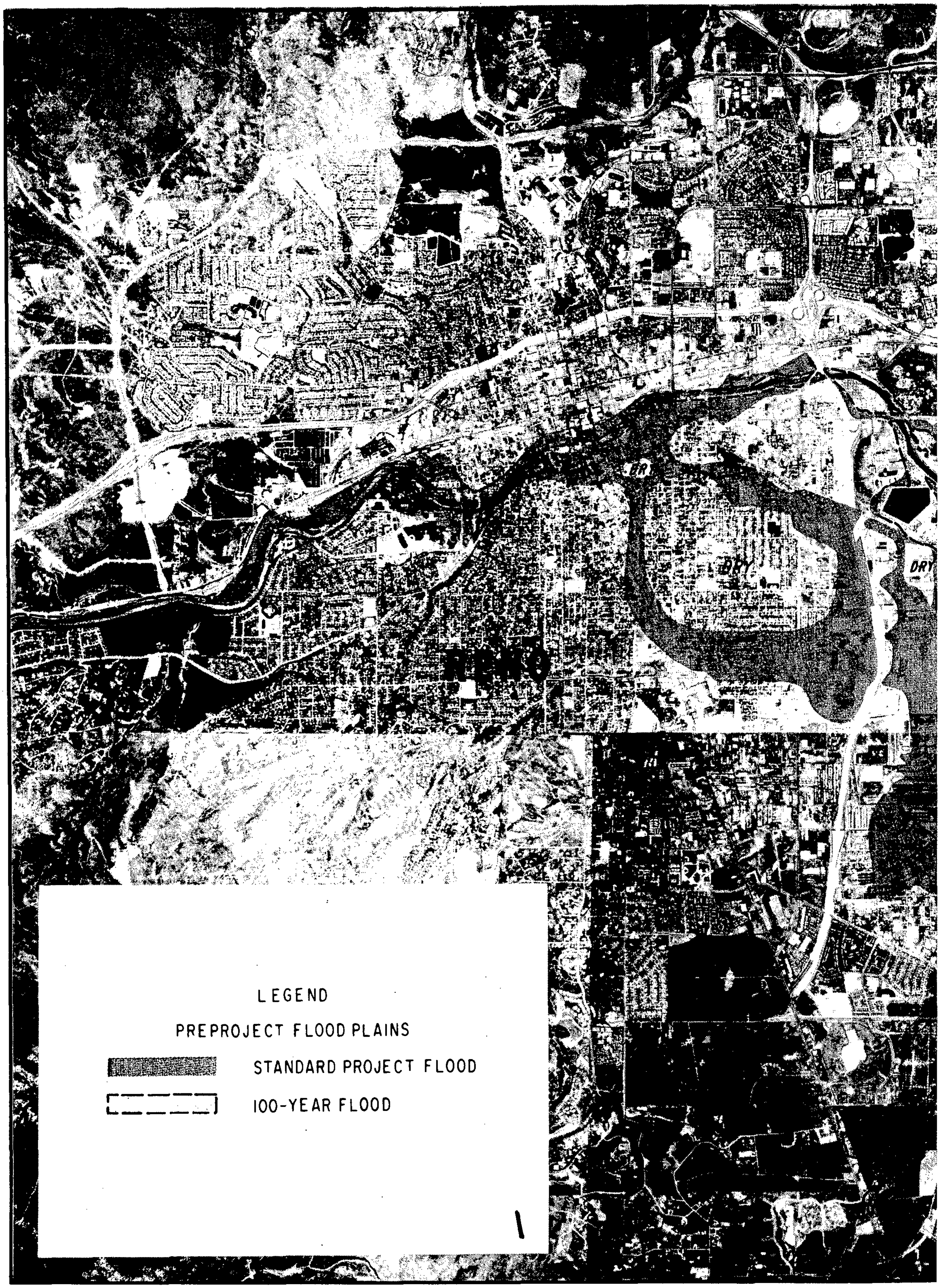


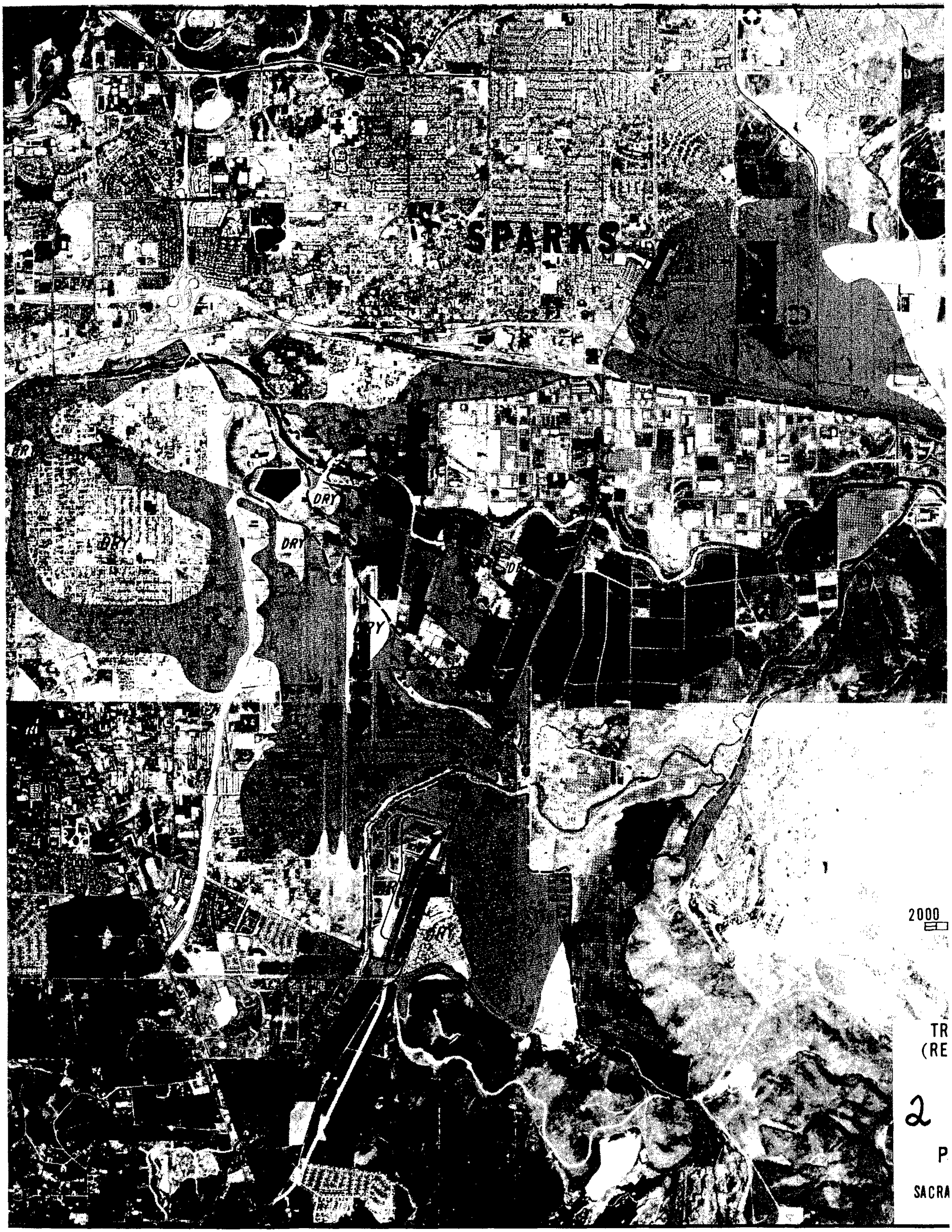
TRUCKEE MEADOWS INVESTIGATION
(RENO-SPARKS METROPOLITAN AREA)
NEVADA

GENERAL MAP
STUDY AREA

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

PLATE 1


DRY
DRY
LEGEND
PREPROJECT FLOOD PLAINS
STANDARD PROJECT FLOOD
100-YEAR FLOOD
1


SPARKS
DRY
DRY
DRY
DRY
DRY
DRY
2000
TR
(RE
2
P
SACRA

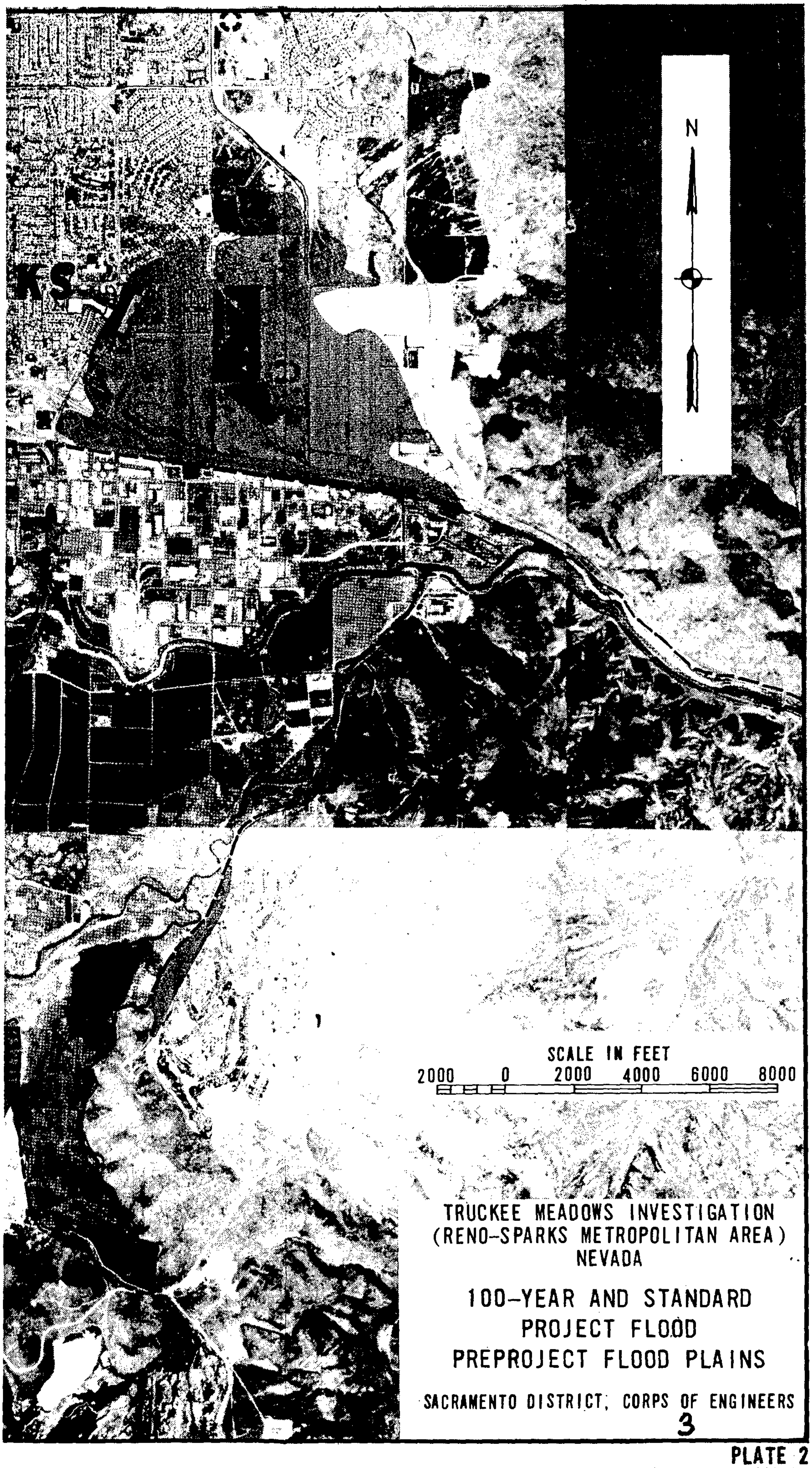
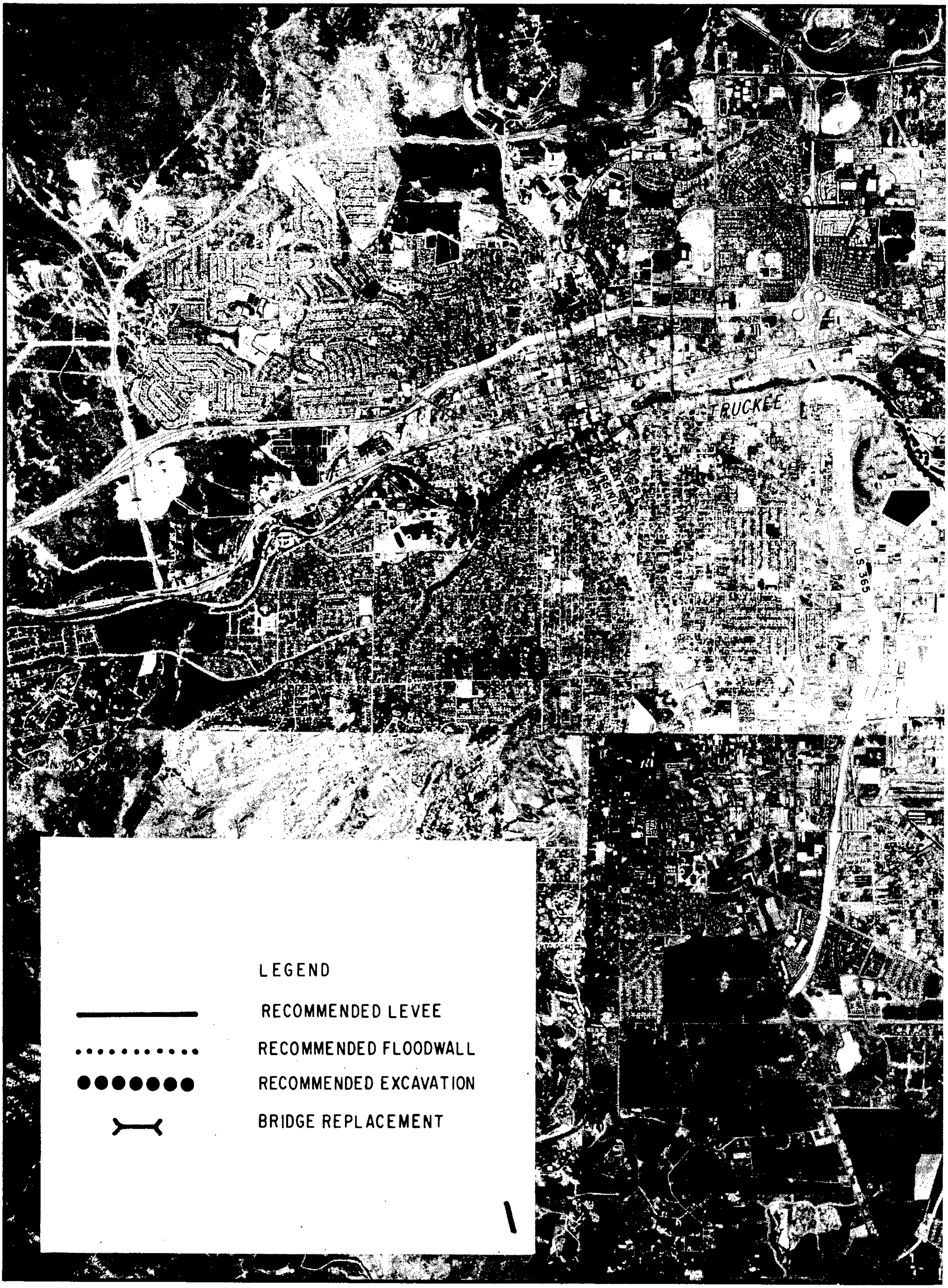
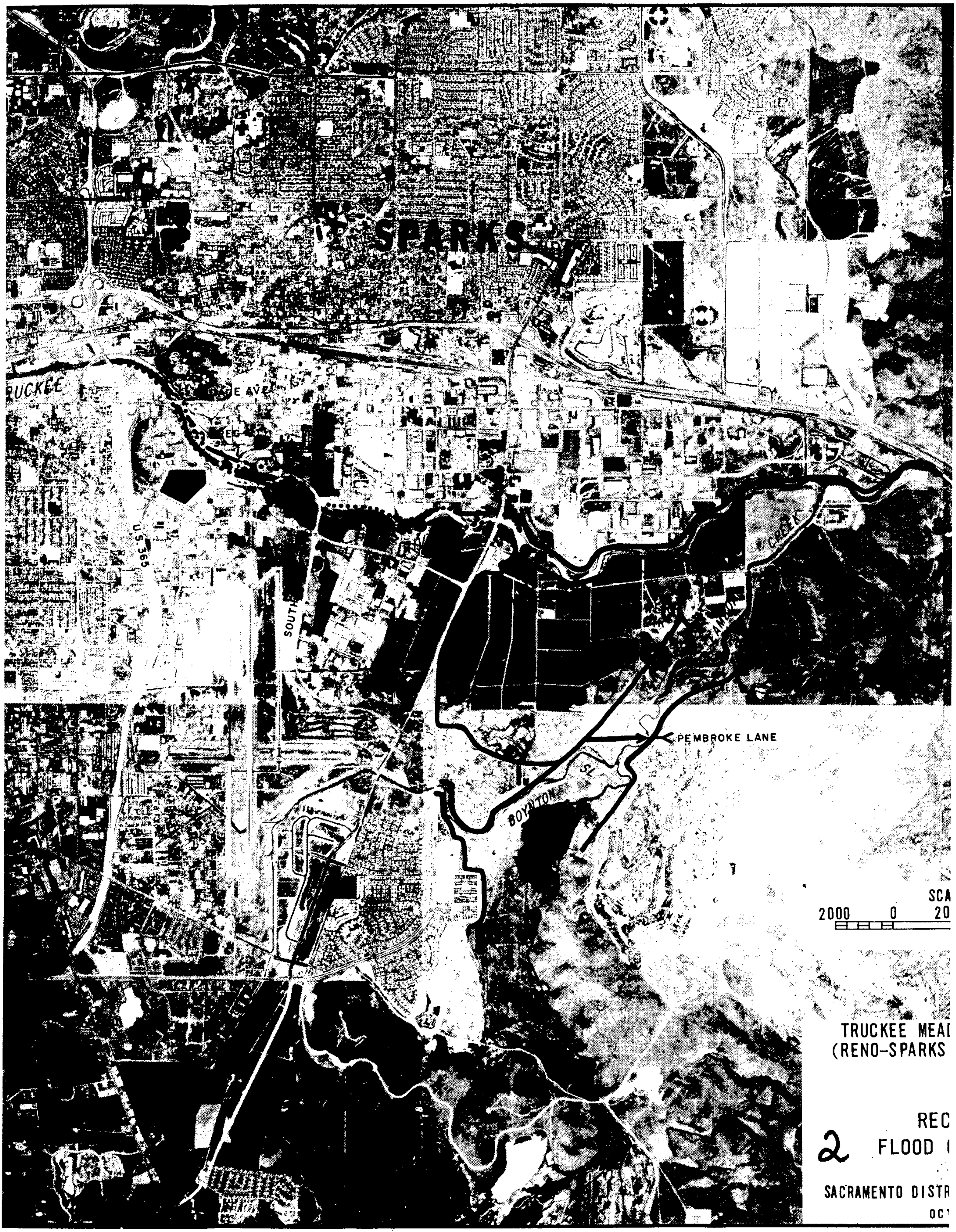
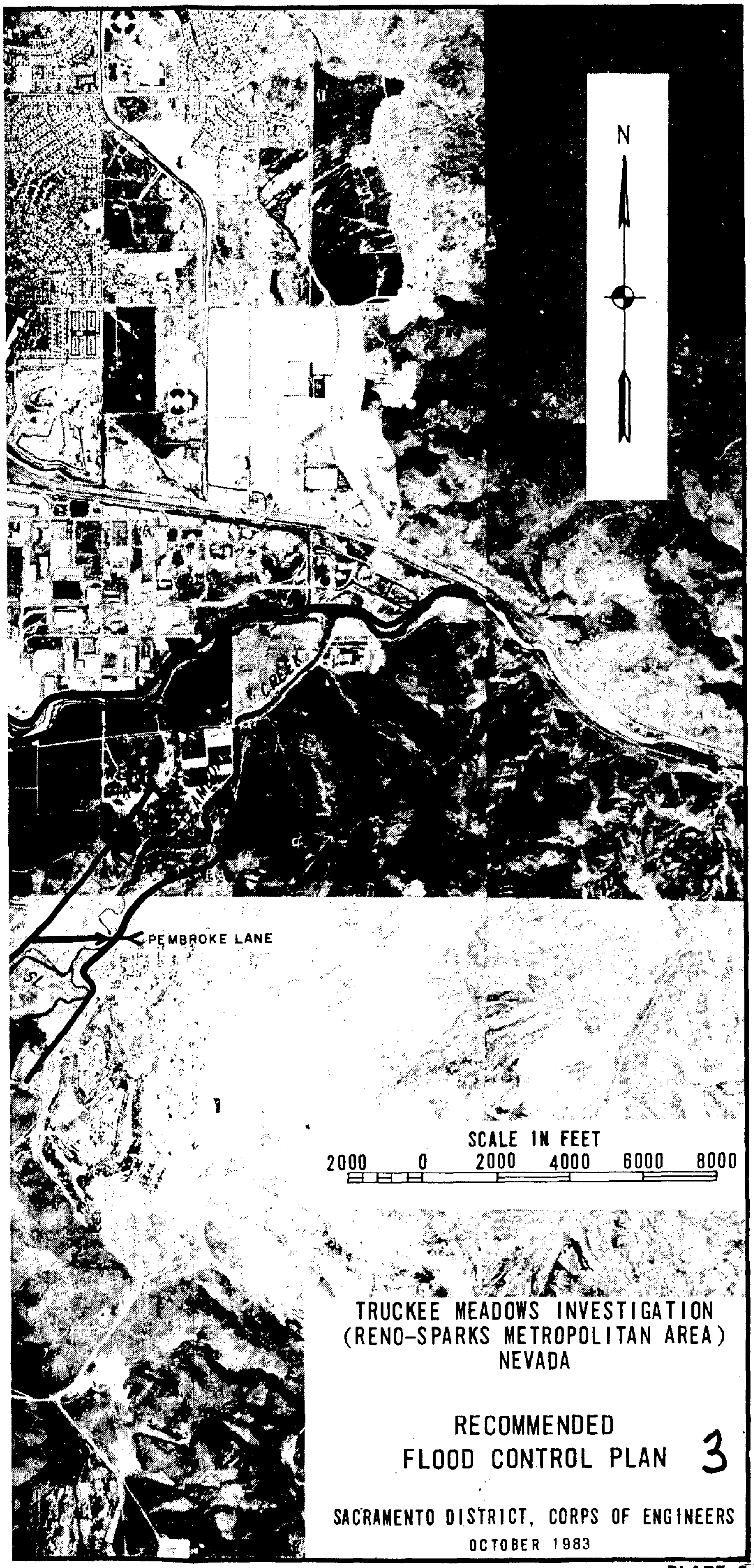

N
SCALE IN FEET
2000 0 2000 4000 6000 8000
TRUCKEE MEADOWS INVESTIGATION
(RENO-SPARKS METROPOLITAN AREA)
NEVADA
100-YEAR AND STANDARD
PROJECT FLOOD
PREPROJECT FLOOD PLAINS
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
3

PLATE 2


TRUCKEE
VIRGINIA
SIERRA ST.
U.S. 365
LEGEND
RECOMMENDED LEVEE
RECOMMENDED FLOODWALL
RECOMMENDED EXCAVATION
BRIDGE REPLACEMENT
1


SPARKS
RUCKEE
U.S. 395
SOUTH
CREEK
PEMBROKE LANE
BOYNTON SL
SCA
2000 0 20
TRUCKEE MEAI
(RENO-SPARKS
REC
2 FLOOD
SACRAMENTO DISTR
OC

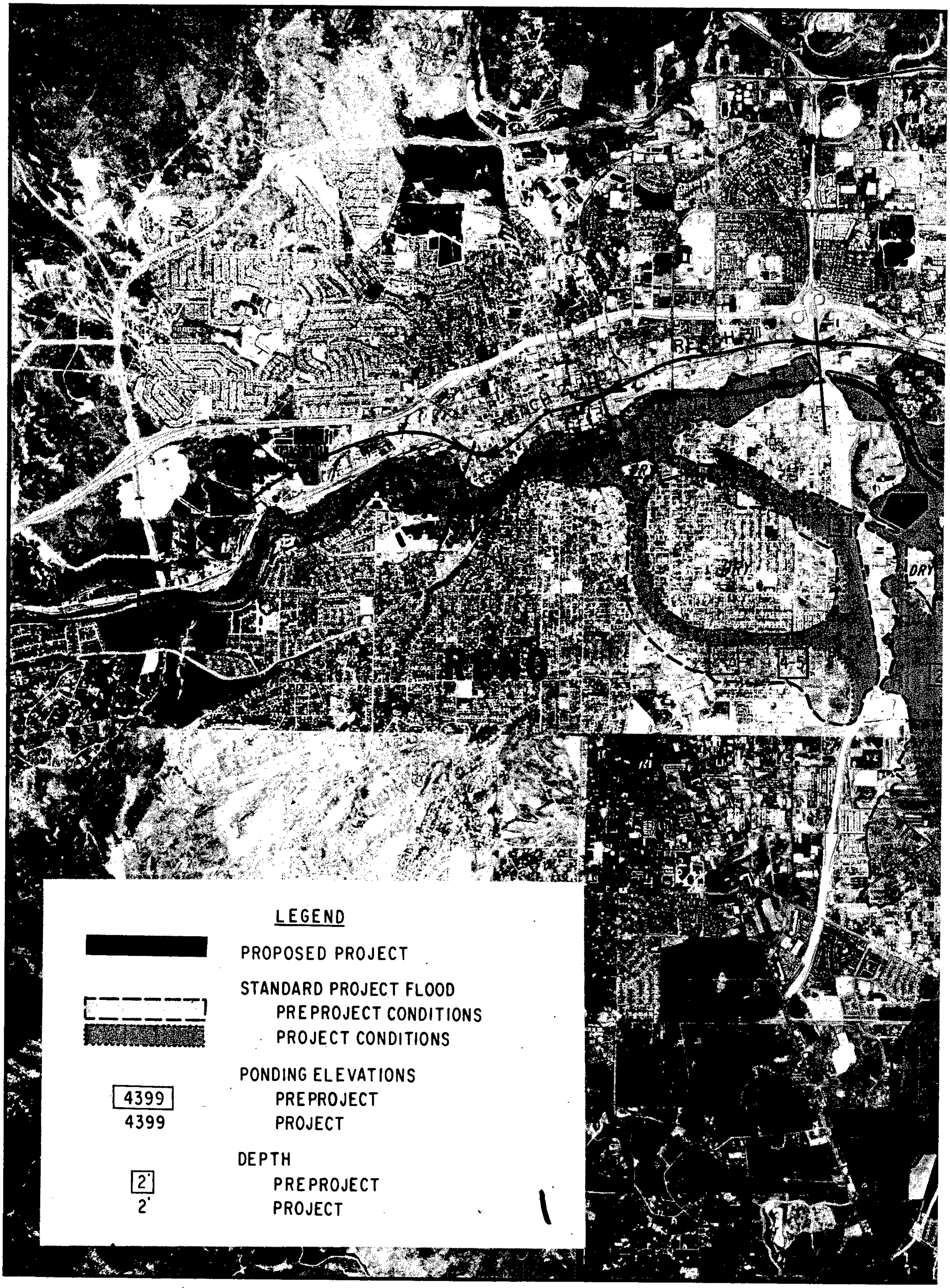


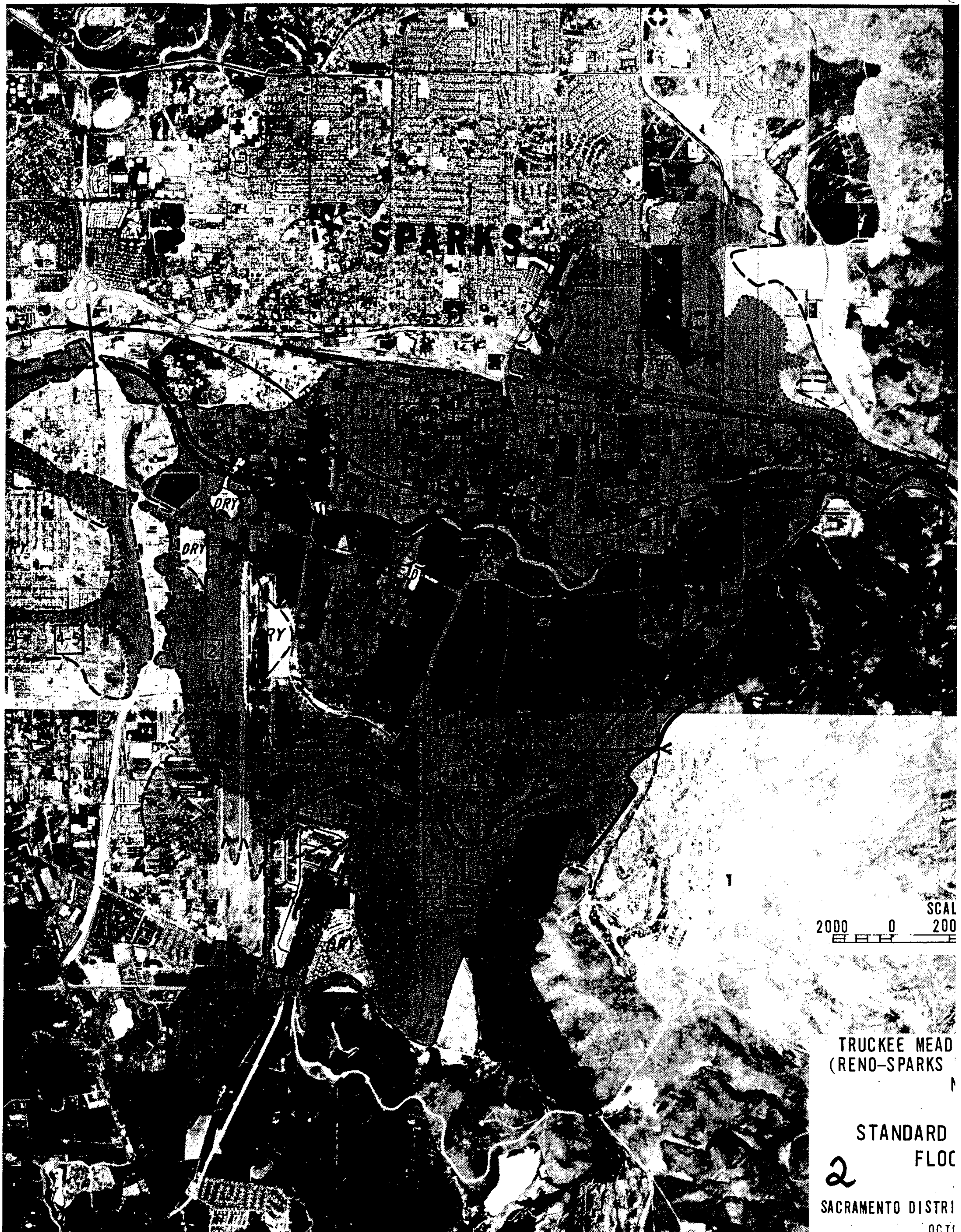
TRUCKEE MEADOWS INVESTIGATION
(RENO-SPARKS METROPOLITAN AREA)
NEVADA

RECOMMENDED
FLOOD CONTROL PLAN 3

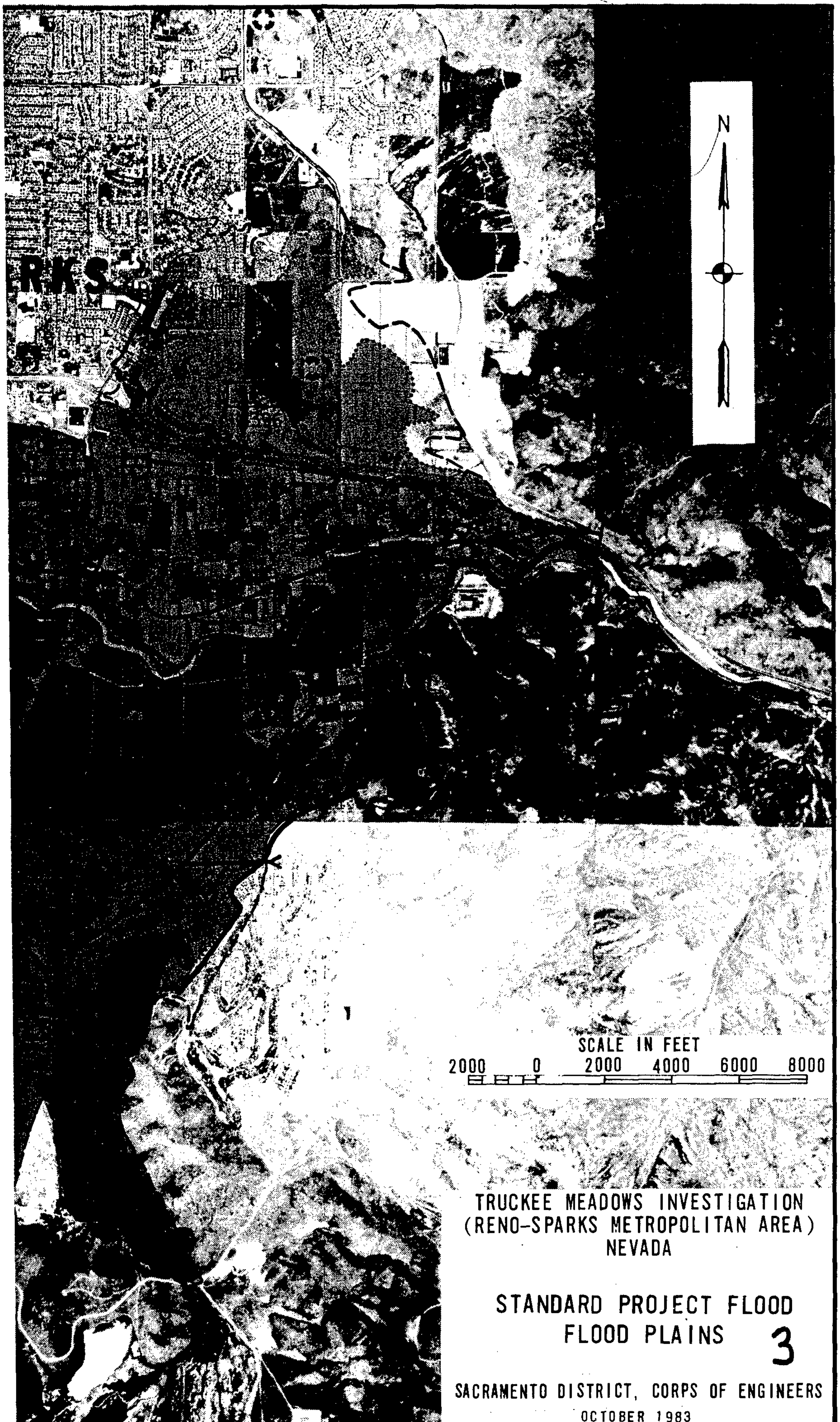
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

PLATE 3


LEGEND
PROPOSED PROJECT
STANDARD PROJECT FLOOD
PREPROJECT CONDITIONS
PROJECT CONDITIONS
PONDING ELEVATIONS
4399
PREPROJECT
4399
PROJECT
DEPTH
2'
PREPROJECT
2'
PROJECT
DRY
DRY



SPARKS
DRY
DRY
DRY
SCAL
2000 0 200
TRUCKEE MEAD
(RENO-SPARKS
STANDARD
FLOC
2
SACRAMENTO DISTRI
OCT

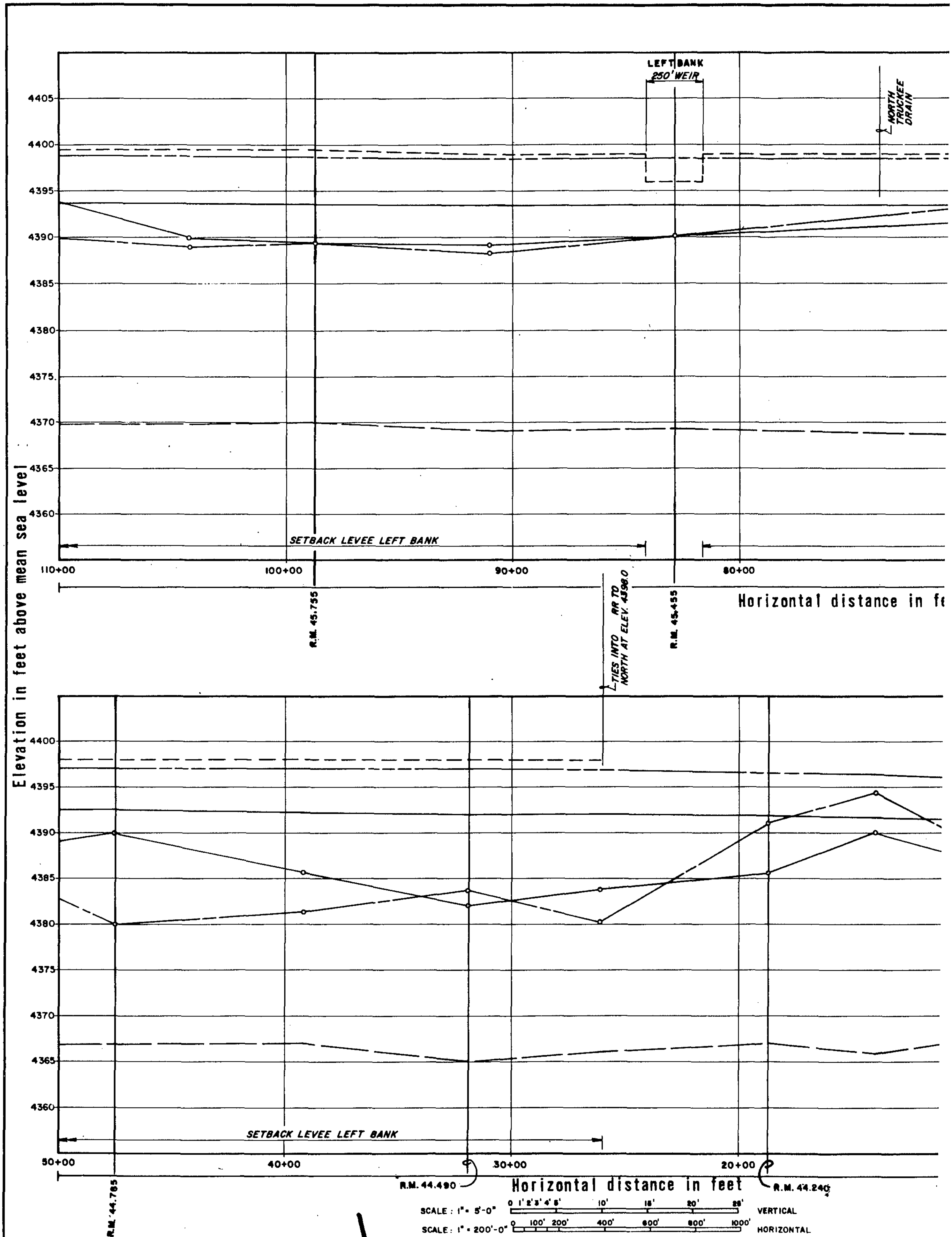


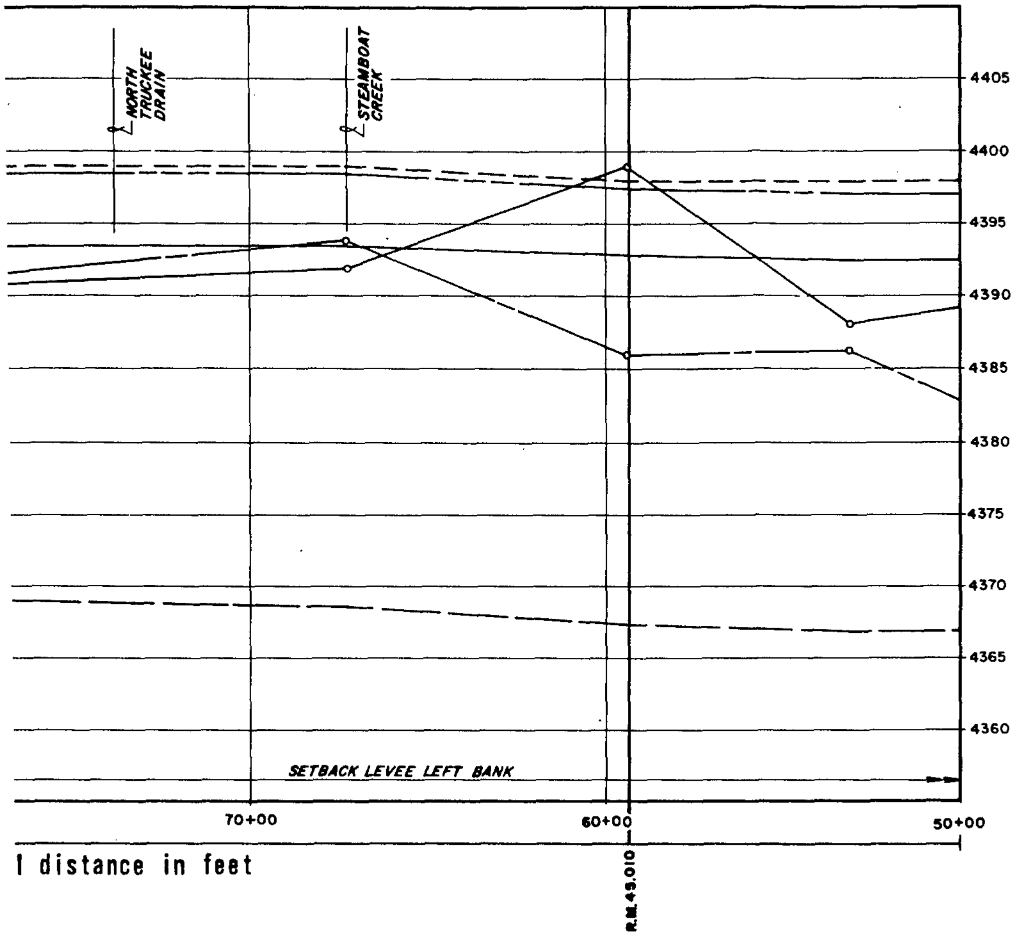
TRUCKEE MEADOWS INVESTIGATION
(RENO-SPARKS METROPOLITAN AREA)
NEVADA

STANDARD PROJECT FLOOD
FLOOD PLAINS 3

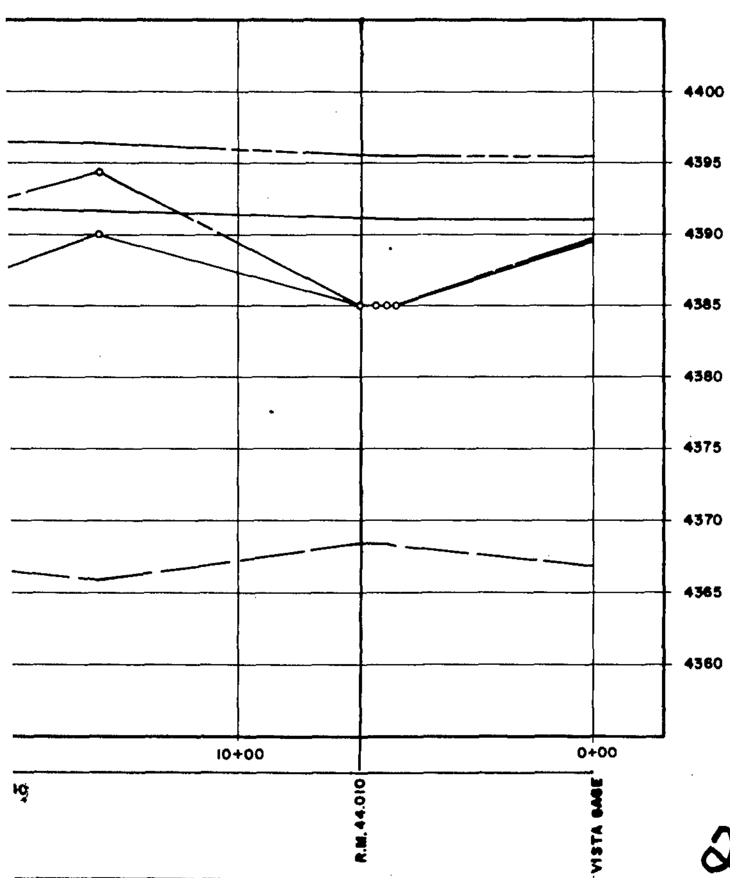
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

PLATE 4


LEFT BANK
250' WEIR
NORTH TRUCKEE DRAIN
4405
4400
4395
4390
4385
4380
4375
4370
4365
4360
SETBACK LEVEE LEFT BANK
110+00
100+00
90+00
80+00
R.M. 45.755
TIES INTO RR TO NORTH AT ELEV. 4398.0
R.M. 45.455
Horizontal distance in fe
Elevation in feet above mean sea level
4400
4395
4390
4385
4380
4375
4370
4365
4360
SETBACK LEVEE LEFT BANK
50+00
40+00
30+00
20+00
R.M. 44.765
R.M. 44.490
R.M. 44.240
Horizontal distance in feet
SCALE : 1" = 5'-0"
0 1' 2' 3' 4' 5' 10' 15' 20' 25'
VERTICAL
SCALE : 1" = 200'-0"
0 100' 200' 400' 600' 800' 1000'
HORIZONTAL



l distance in feet



LEGEND

- 100 YEAR FLOOD
- STANDARD PROJECT FLOOD
- EXISTING LEFT BANK
- EXISTING RIGHT BANK
- CHANNEL INVERT
- IMPROVEMENTS/LEFT BANK
- IMPROVEMENTS/RIGHT BANK
- IMPROVEMENTS/LEFT & RIGHT BANKS
- 44.010 – RIVER MILE (R.M. BEGINS AT PYRAMID LAKE).

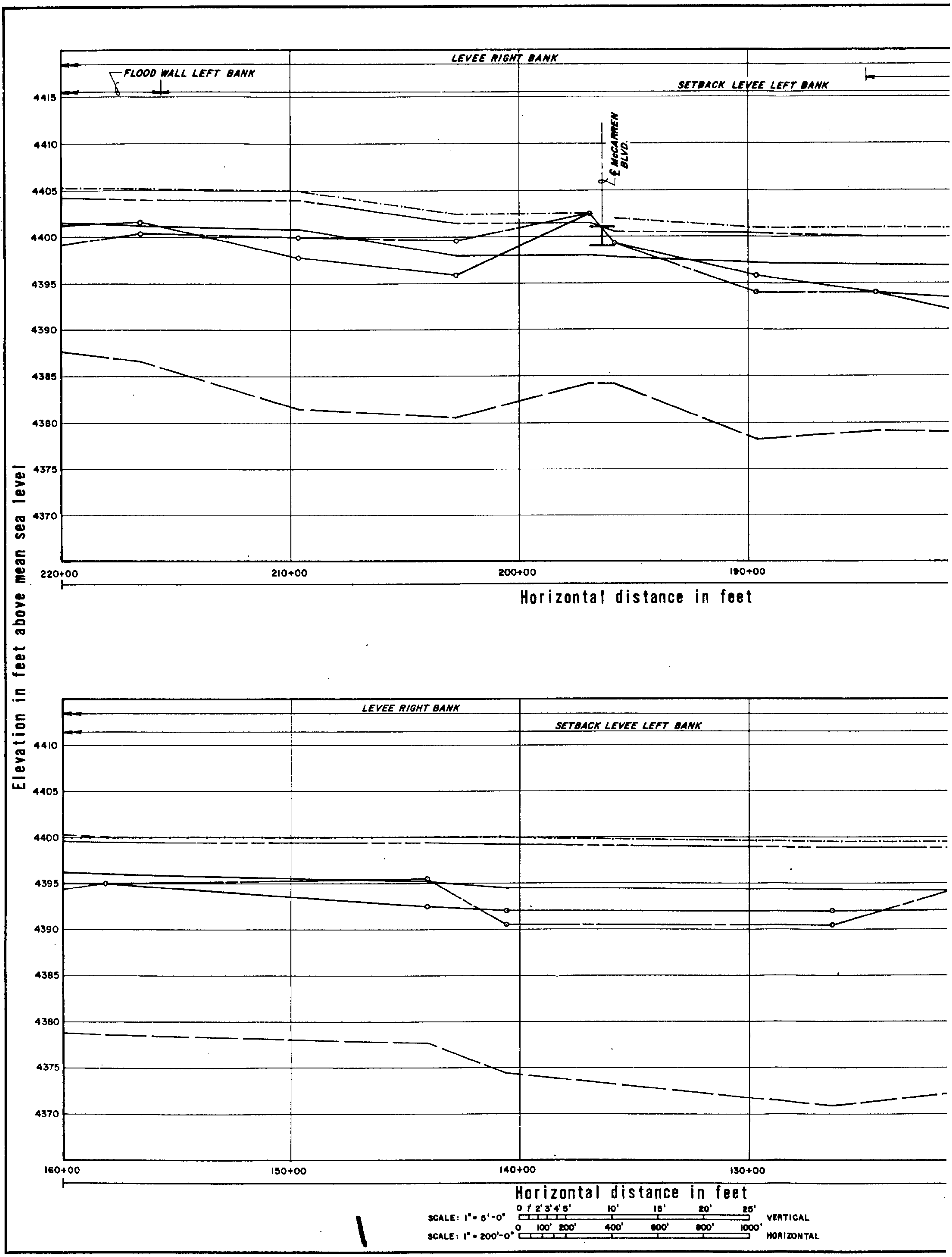
TRUCKEE MEADOWS INVESTIGATION
RENO-SPARKS METROPOLITAN AREA, NEVADA

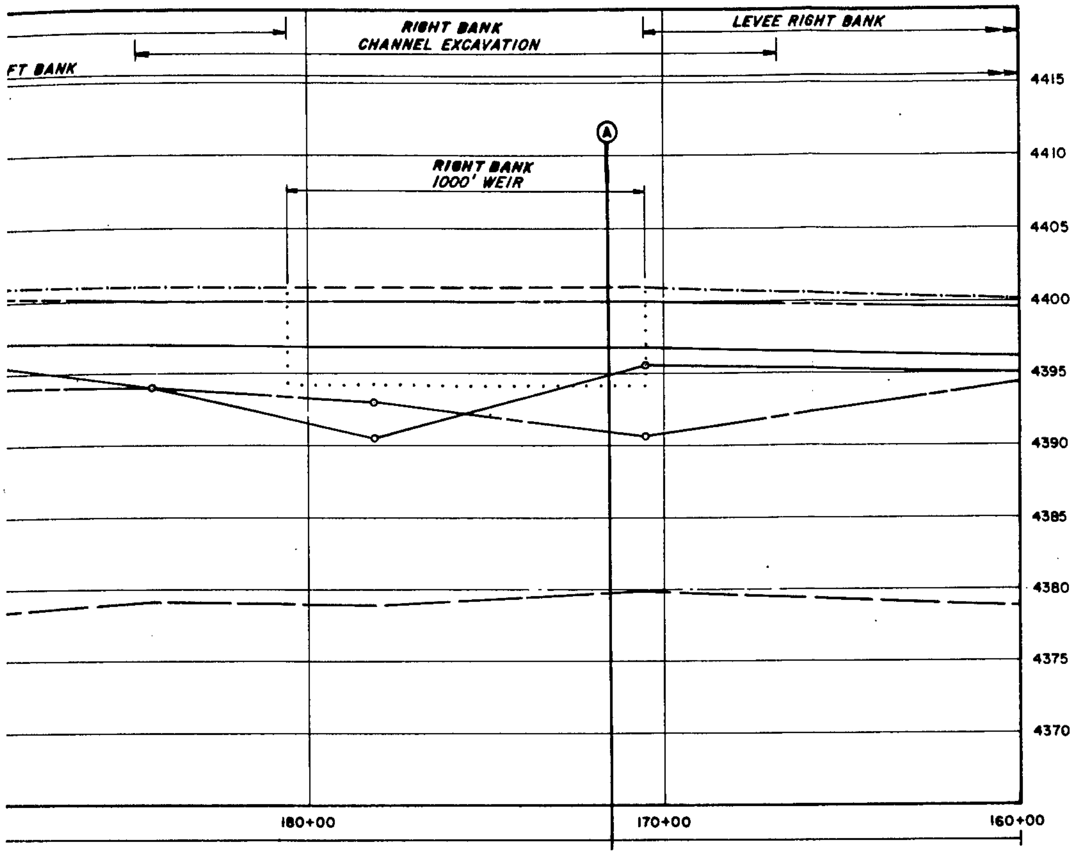
TRUCKEE RIVER
PROFILE
STA. 0+00 to STA. 110+00

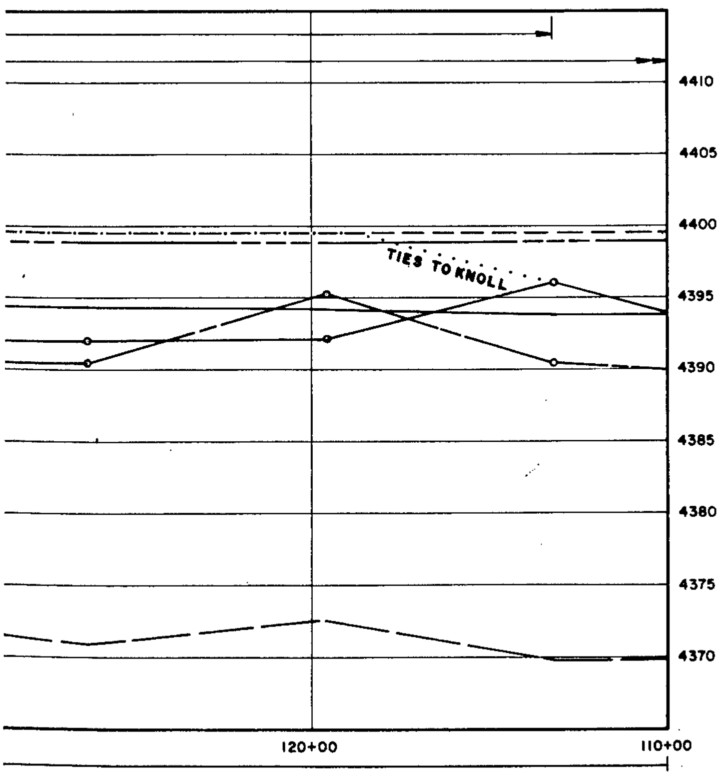
2

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

PLATE 5


LEVEE RIGHT BANK
FLOOD WALL LEFT BANK
SETBACK LEVEE LEFT BANK
℄ McCARREN BLVD.
4415
4410
4405
4400
4395
4390
4385
4380
4375
4370
220+00
210+00
200+00
190+00
Horizontal distance in feet
Elevation in feet above mean sea level
LEVEE RIGHT BANK
SETBACK LEVEE LEFT BANK
160+00
150+00
140+00
130+00
Horizontal distance in feet
SCALE: 1" = 5'-0"
VERTICAL
SCALE: 1" = 200'-0"
HORIZONTAL





RTICAL

RIZONTAL

2

LEGEND

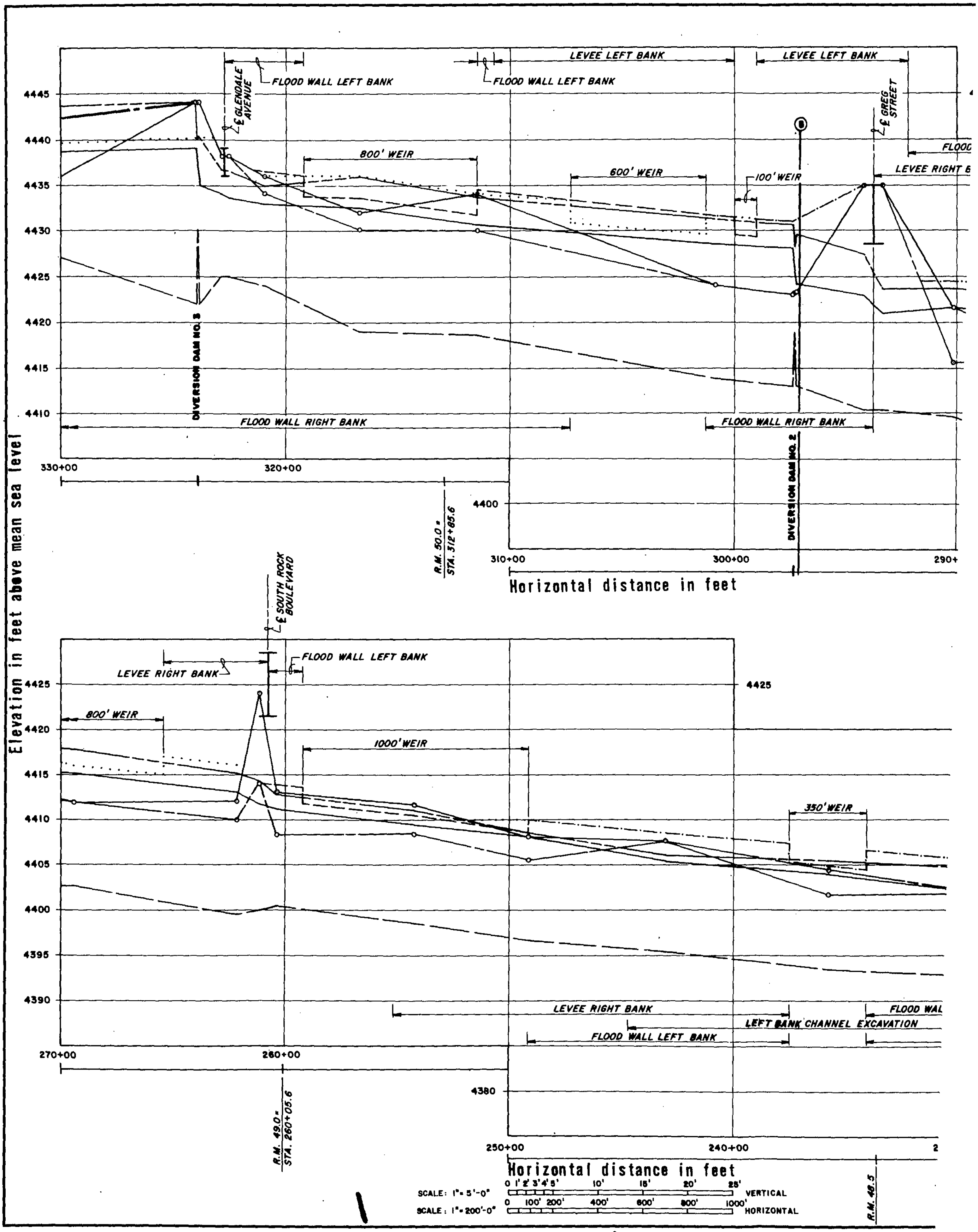
- 100 YEAR FLOOD
- STANDARD PROJECT FLOOD
- EXISTING LEFT BANK
- EXISTING RIGHT BANK
- CHANNEL INVERT
- IMPROVEMENTS/LEFT BANK
- IMPROVEMENTS/RIGHT BANK
- IMPROVEMENTS/LEFT & RIGHT BANKS
- Ⓐ CROSS SECTION

TRUCKEE MEADOWS INVESTIGATION
RENO-SPARKS METROPOLITAN AREA, NEVADA

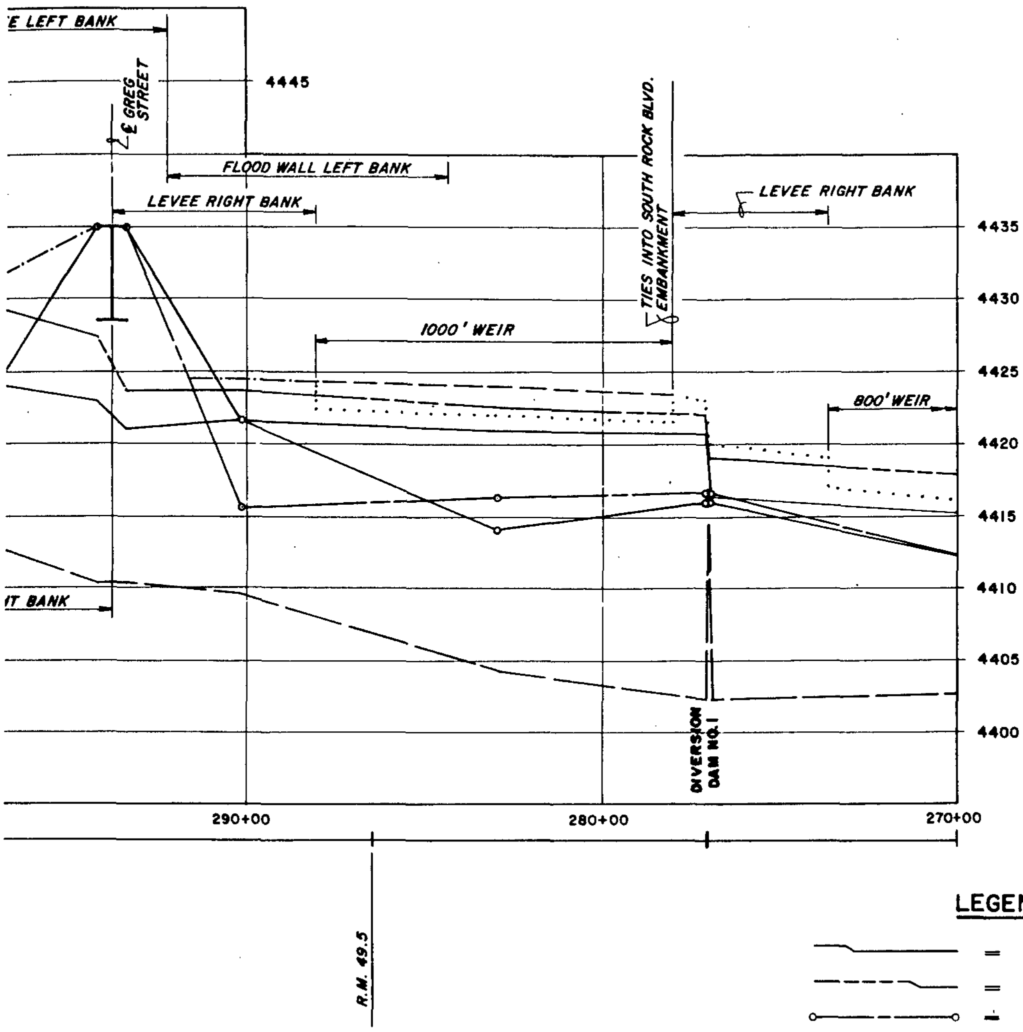
TRUCKEE RIVER
PROFILE
STA. 110+00 to STA. 220+00

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

PLATE 6

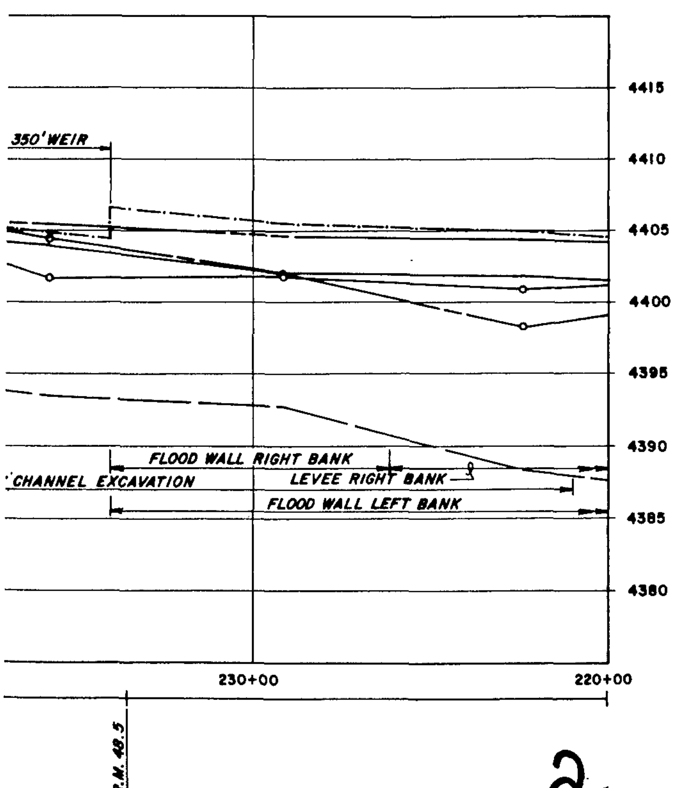


LEVEE LEFT BANK
LEVEE LEFT BANK
FLOOD WALL LEFT BANK
FLOOD WALL LEFT BANK
℄ GLENDALE AVENUE
℄ GREG STREET
800' WEIR
600' WEIR
100' WEIR
LEVEE RIGHT B
FLOOD
DIVERSION DAM NO. 3
DIVERSION DAM NO. 2
FLOOD WALL RIGHT BANK
FLOOD WALL RIGHT BANK
4445
4440
4435
4430
4425
4420
4415
4410
4400
330+00
320+00
310+00
300+00
290+
R.M. 50.0 = STA. 312+85.6
Horizontal distance in feet
Elevation in feet above mean sea level
℄ SOUTH ROCK BOULEVARD
LEVEE RIGHT BANK
FLOOD WALL LEFT BANK
800' WEIR
1000' WEIR
350' WEIR
4425
4420
4415
4410
4405
4400
4395
4390
4380
LEVEE RIGHT BANK
LEFT BANK CHANNEL EXCAVATION
FLOOD WALL LEFT BANK
FLOOD WAL
270+00
260+00
250+00
240+00
R.M. 49.0 = STA. 260+05.6
R.M. 48.5
Horizontal distance in feet
SCALE: 1" = 5'-0"
SCALE: 1" = 200'-0"
VERTICAL
HORIZONTAL



LEGEND

100 YEAR FLOOD		
STANDARD PROJECT FLOOD		
EXISTING LEFT BANK		
EXISTING RIGHT BANK		
CHANNEL INVERT		
IMPROVEMENTS/LEFT BANK		
IMPROVEMENTS/RIGHT BANK		
IMPROVEMENTS/LEFT & RIGHT BANK		
CROSS SECTION		



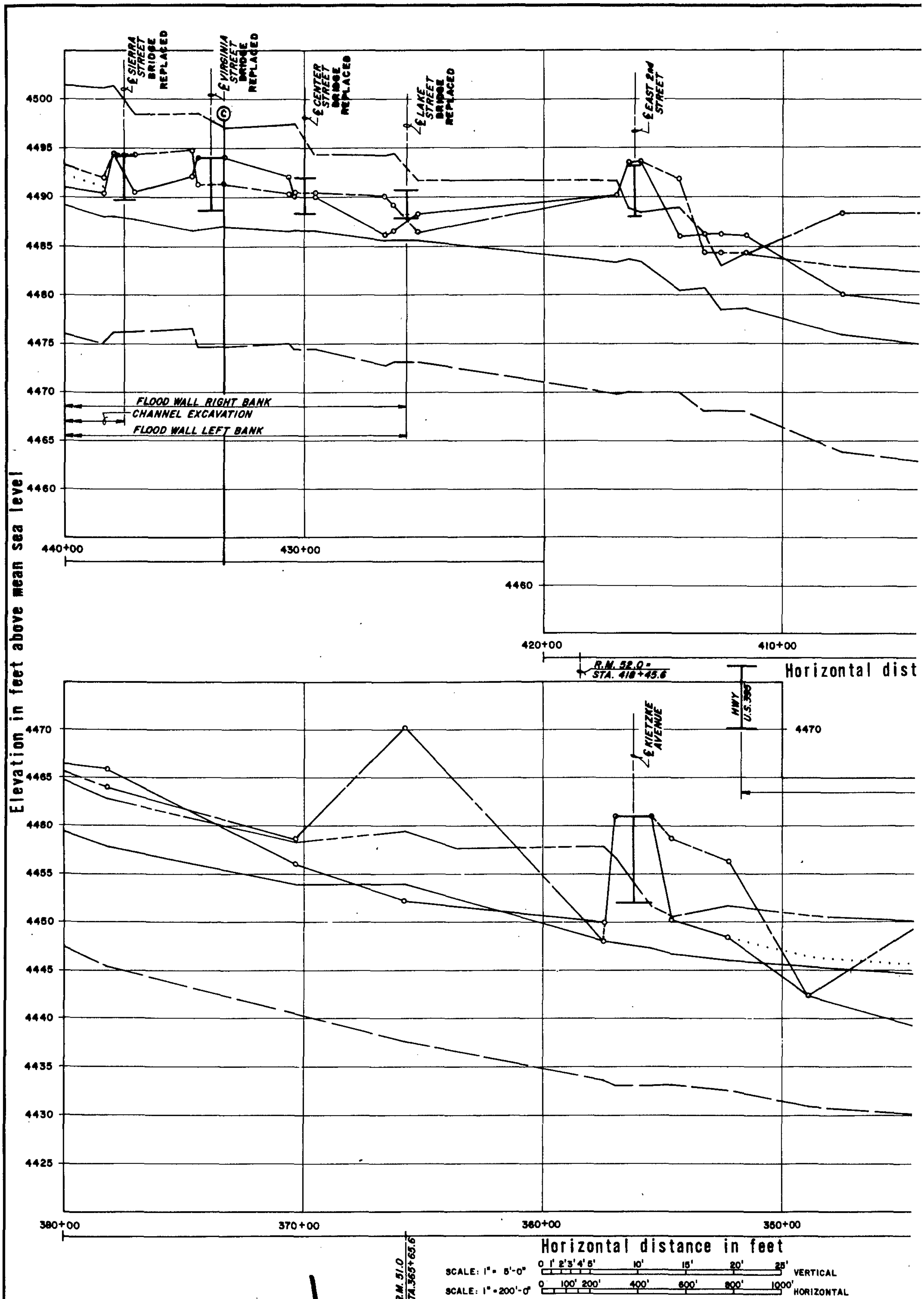
TRUCKEE MEADOWS INVESTIGATION
RENO-SPARKS METROPOLITAN AREA, NEVADA

TRUCKEE RIVER
PROFILE
STA. 220+00 to STA. 330+00

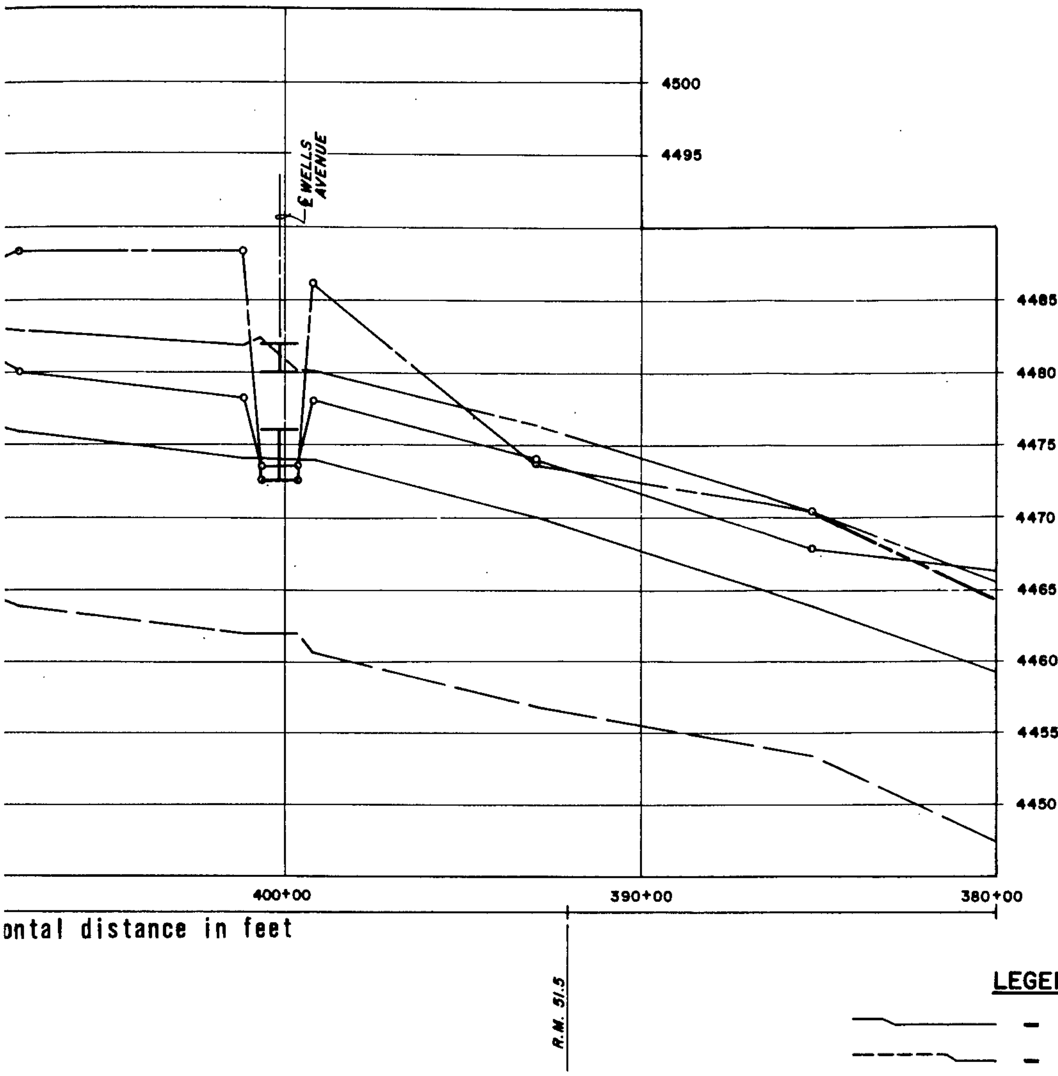
2

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

PLATE 7

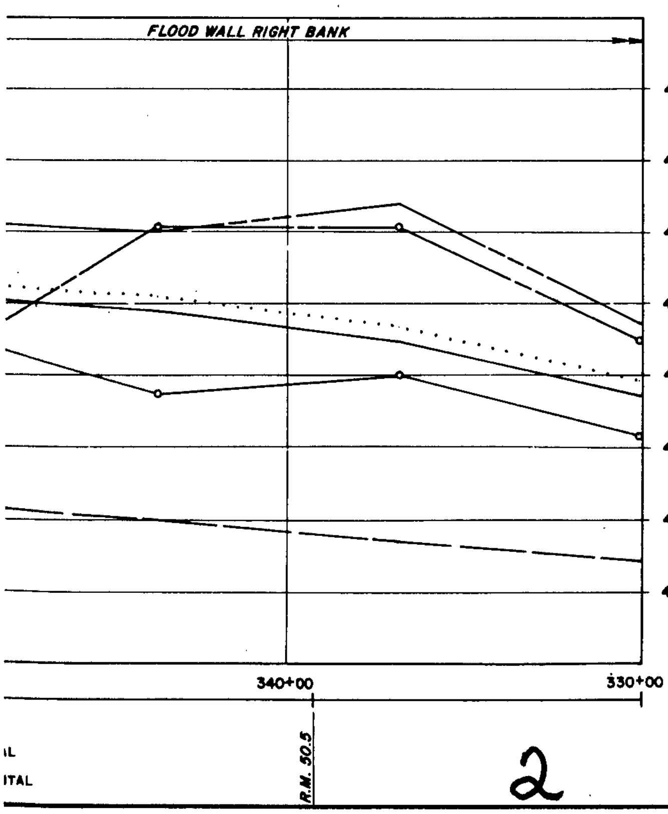


℄ SIERRA STREET BRIDGE REPLACED
℄ VIRGINIA STREET BRIDGE REPLACED
℄ CENTER STREET BRIDGE REPLACED
℄ LAKE STREET BRIDGE REPLACED
℄ EAST 2nd STREET
FLOOD WALL RIGHT BANK
CHANNEL EXCAVATION
FLOOD WALL LEFT BANK
4500
4495
4490
4485
4480
4475
4470
4465
4460
440+00
430+00
420+00
410+00
R.M. 52.0 = STA. 418+45.6
HWY U.S. 395
Horizontal dist
℄ KIETZKE AVENUE
4455
4450
4445
4440
4435
4430
4425
380+00
370+00
360+00
350+00
R.M. 51.0 STA. 365+65.6
Elevation in feet above mean sea level
Horizontal distance in feet
SCALE: 1" = 5'-0"
0 1' 2' 3' 4' 5' 10' 15' 20' 25' VERTICAL
SCALE: 1" = 200'-0"
0 100' 200' 400' 600' 800' 1000' HORIZONTAL



LEGEND

	—	100 YEAR FLOOD
	—	STANDARD PROJECT FLOOD
	—	EXISTING LEFT BANK
	—	EXISTING RIGHT BANK
	—	CHANNEL INVERT
	=	IMPROVEMENTS/LEFT BANK
	—	IMPROVEMENTS/RIGHT BANK
	—	IMPROVEMENTS/LEFT & RIGHT BANKS
Ⓒ	=	CROSS SECTION



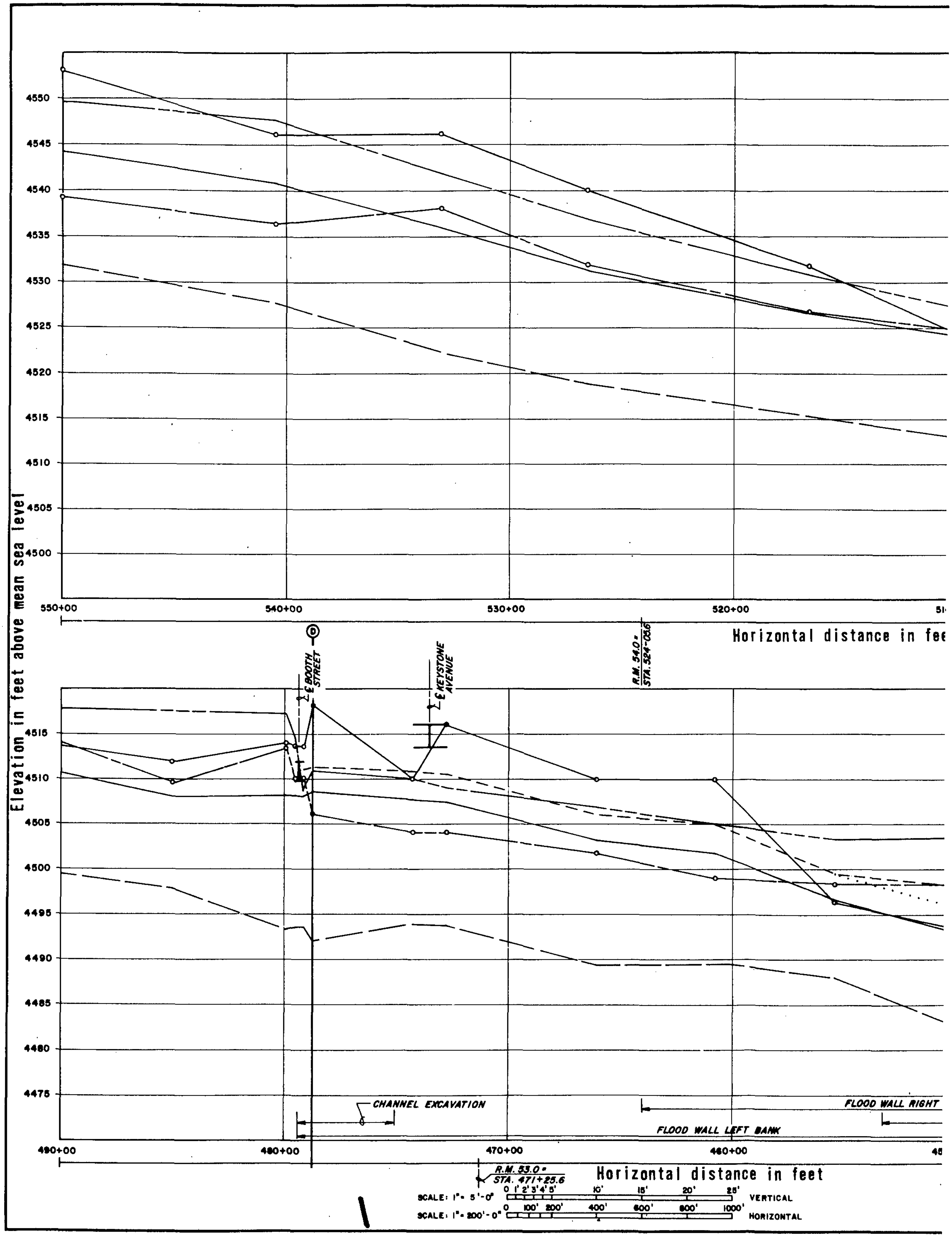
TRUCKEE MEADOWS INVESTIGATION
RENO-SPARKS METROPOLITAN AREA, NEVADA

TRUCKEE RIVER
PROFILE
STA. 330+00 to STA. 440+00

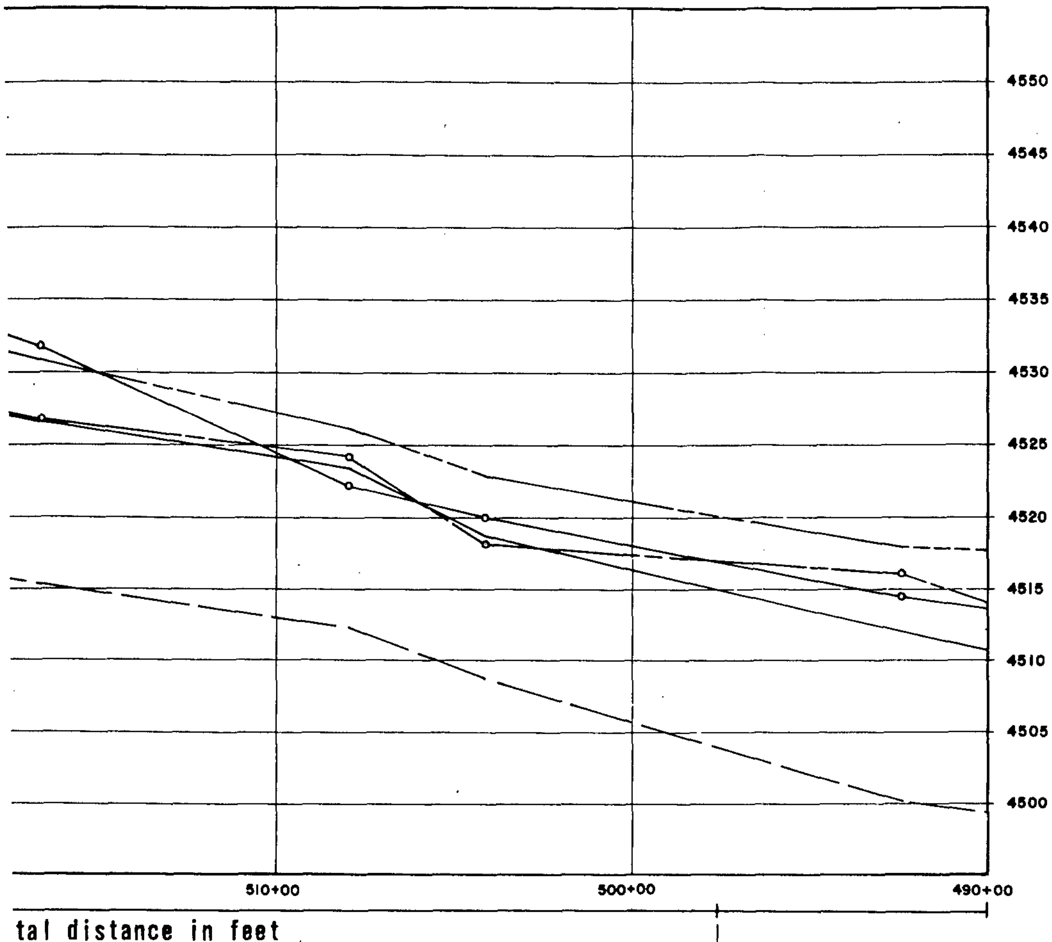
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

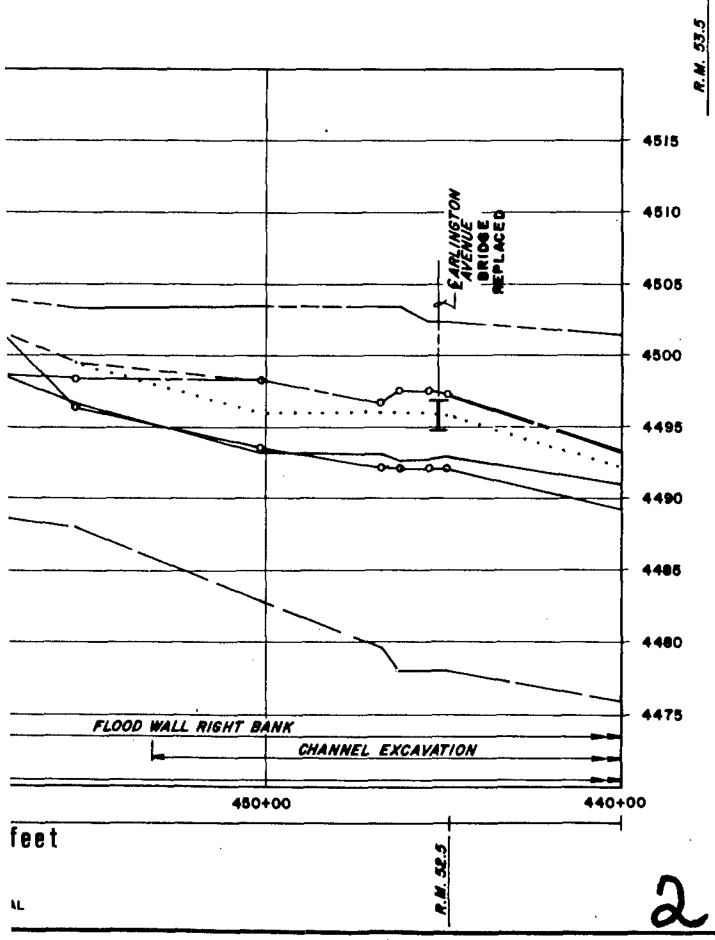
2

PLATE 8



Elevation in feet above mean sea level
4550
4545
4540
4535
4530
4525
4520
4515
4510
4505
4500
550+00
540+00
530+00
520+00
Horizontal distance in fee
Ⓓ
℄ BOOTH STREET
℄ KEYSTONE AVENUE
R.M. 54.0 = STA. 524+05.6
4515
4510
4505
4500
4495
4490
4485
4480
4475
CHANNEL EXCAVATION
FLOOD WALL RIGHT
FLOOD WALL LEFT BANK
490+00
480+00
470+00
460+00
R.M. 53.0 = STA. 471+25.6
Horizontal distance in feet
SCALE: 1" = 5'-0"
0 1' 2' 3' 4' 5' 10' 15' 20' 25'
VERTICAL
SCALE: 1" = 200'-0"
0 100' 200' 400' 600' 800' 1000'
HORIZONTAL





LEGEND

- 100 YEAR FLOOD
- STANDARD PROJECT FLOOD
- EXISTING LEFT BANK
- EXISTING RIGHT BANK
- CHANNEL INVERT
- IMPROVEMENTS - LEFT BANK
- IMPROVEMENTS - RIGHT BANK
- IMPROVEMENTS - LEFT & RIGHT BANKS
- (D) = CROSS SECTION

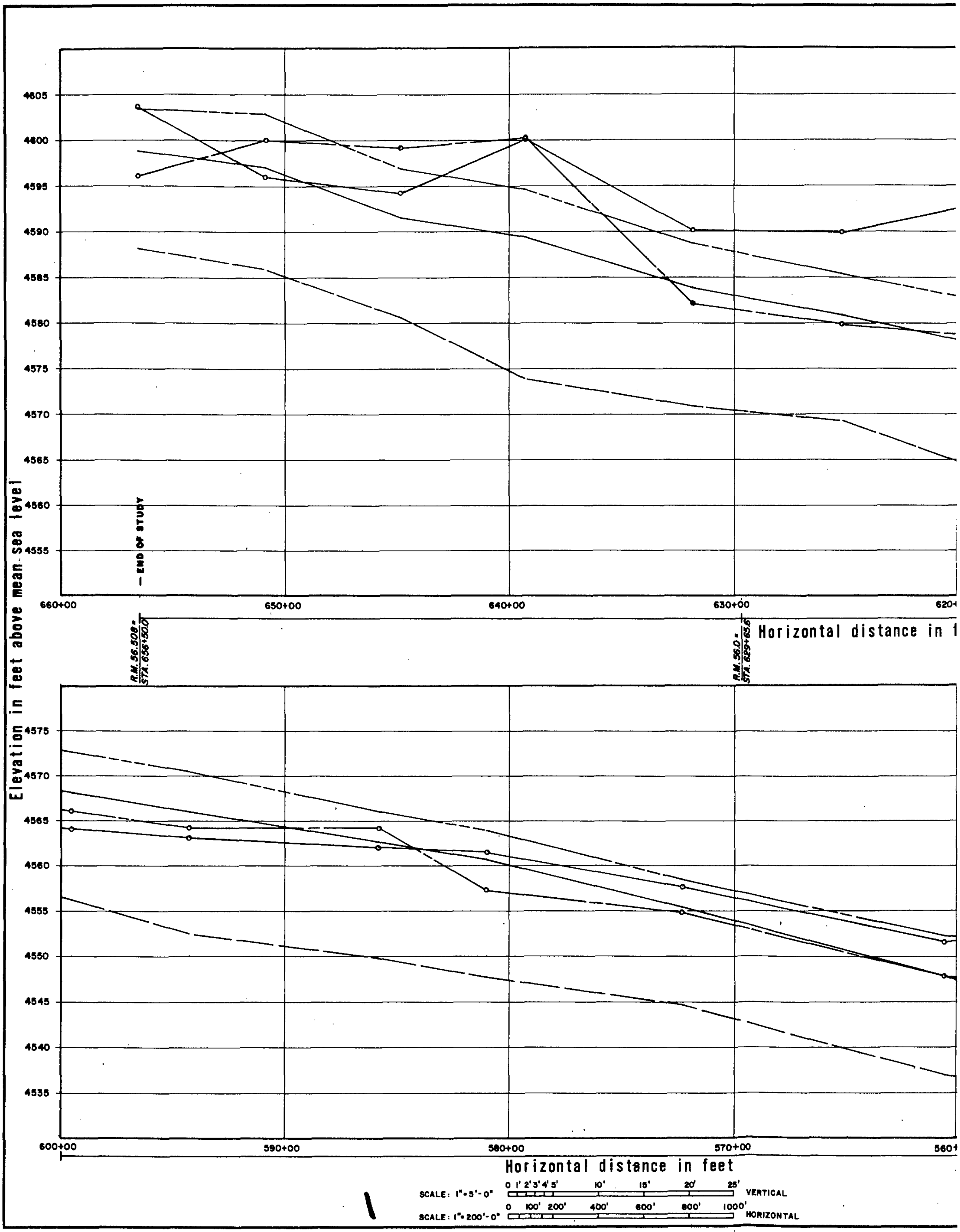
TRUCKEE MEADOWS INVESTIGATION
RENO-SPARKS METROPOLITAN AREA, NEVADA

TRUCKEE RIVER
PROFILE
STA. 440+00 to STA. 550+00

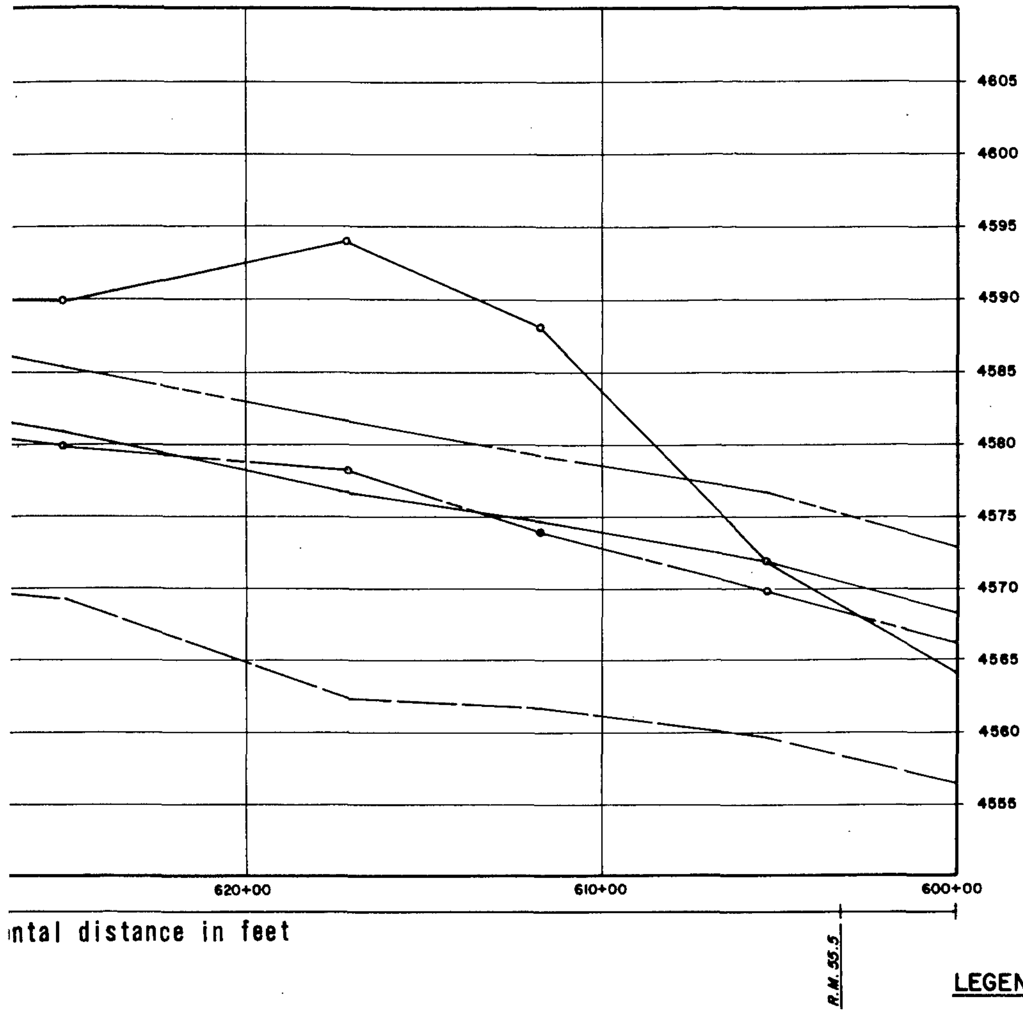
2

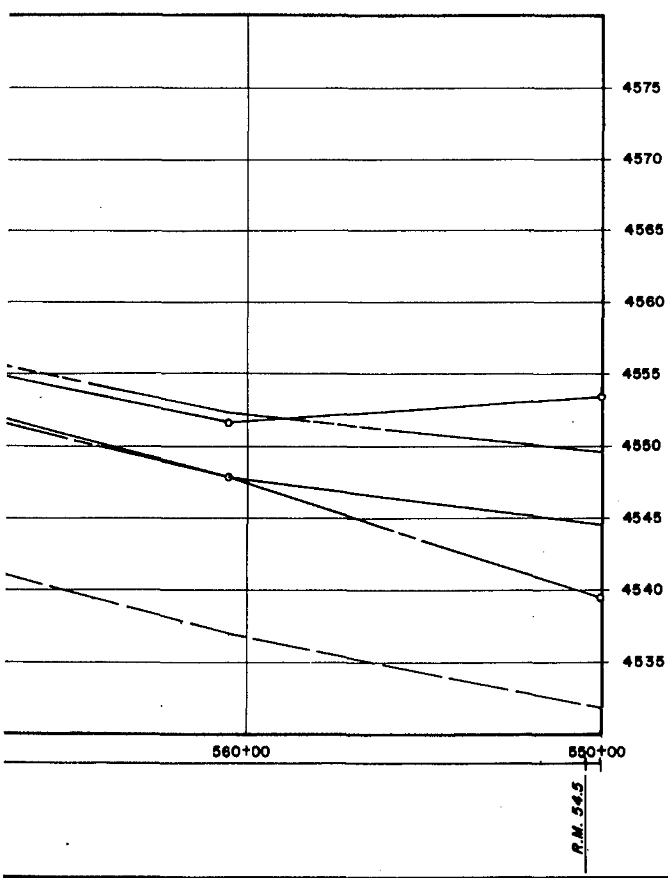
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

PLATE 9



Elevation in feet above mean sea level
4605
4600
4595
4590
4585
4580
4575
4570
4565
4560
4555
END OF STUDY
660+00
650+00
640+00
630+00
620+
R.M. 56.508 = STA. 656+50.0
R.M. 56.0 = STA. 629+65.6
Horizontal distance in f
4575
4570
4565
4560
4555
4550
4545
4540
4535
600+00
590+00
580+00
570+00
560+
Horizontal distance in feet
SCALE: 1" = 5'-0"
0 1' 2' 3' 4' 5' 10' 15' 20' 25'
VERTICAL
SCALE: 1" = 200'-0"
0 100' 200' 400' 600' 800' 1000'
HORIZONTAL





LEGEND

- 100 YEAR FLOOD
- STANDARD PROJECT FLOOD
- EXISTING LEFT BANK
- EXISTING RIGHT BANK
- CHANNEL INVERT
- IMPROVEMENTS/LEFT BANK
- IMPROVEMENTS/RIGHT BANK
- IMPROVEMENTS/LEFT & RIGHT BANKS

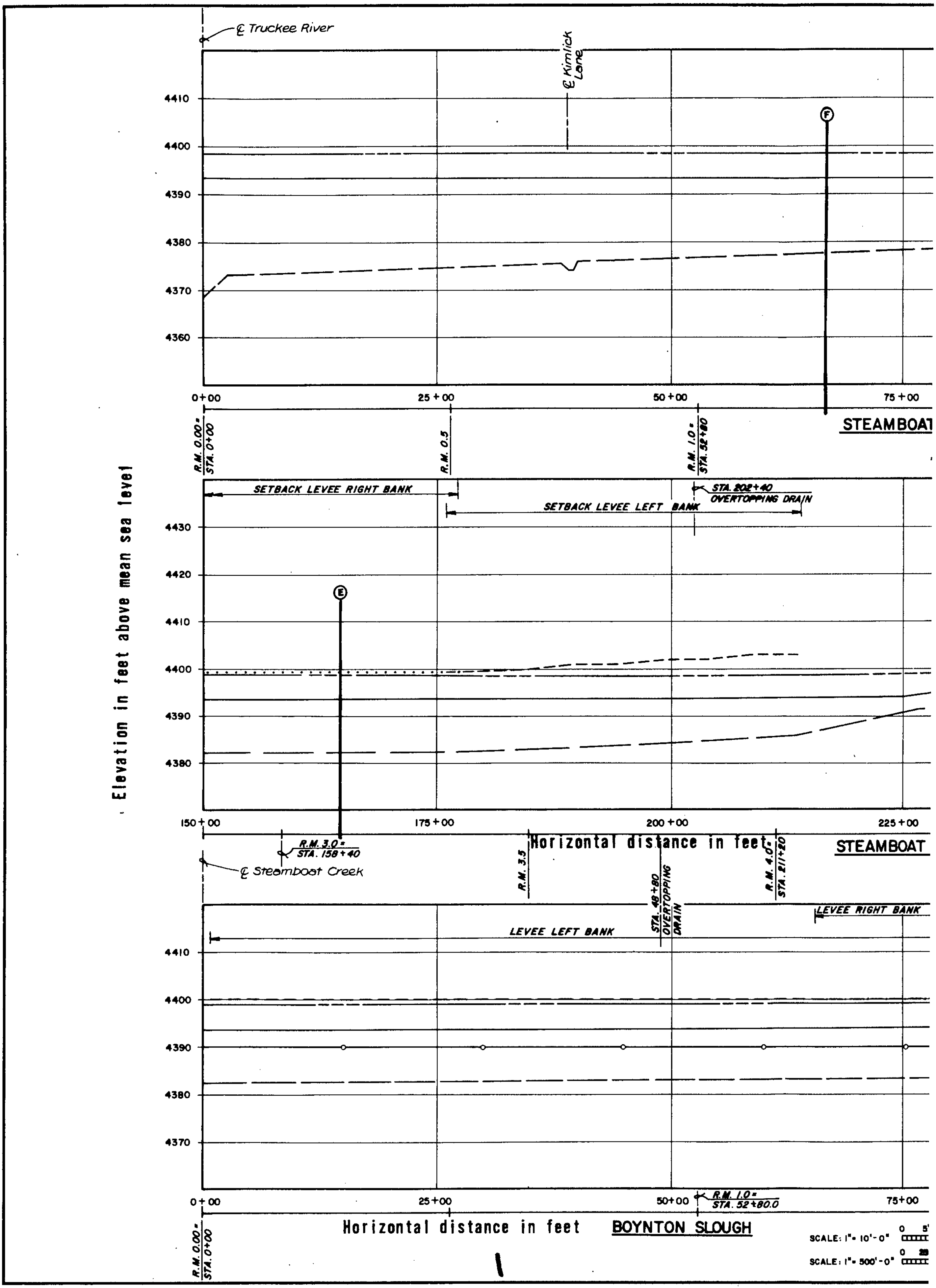
TRUCKEE MEADOWS INVESTIGATION
RENO-SPARKS METROPOLITAN AREA, NEVADA

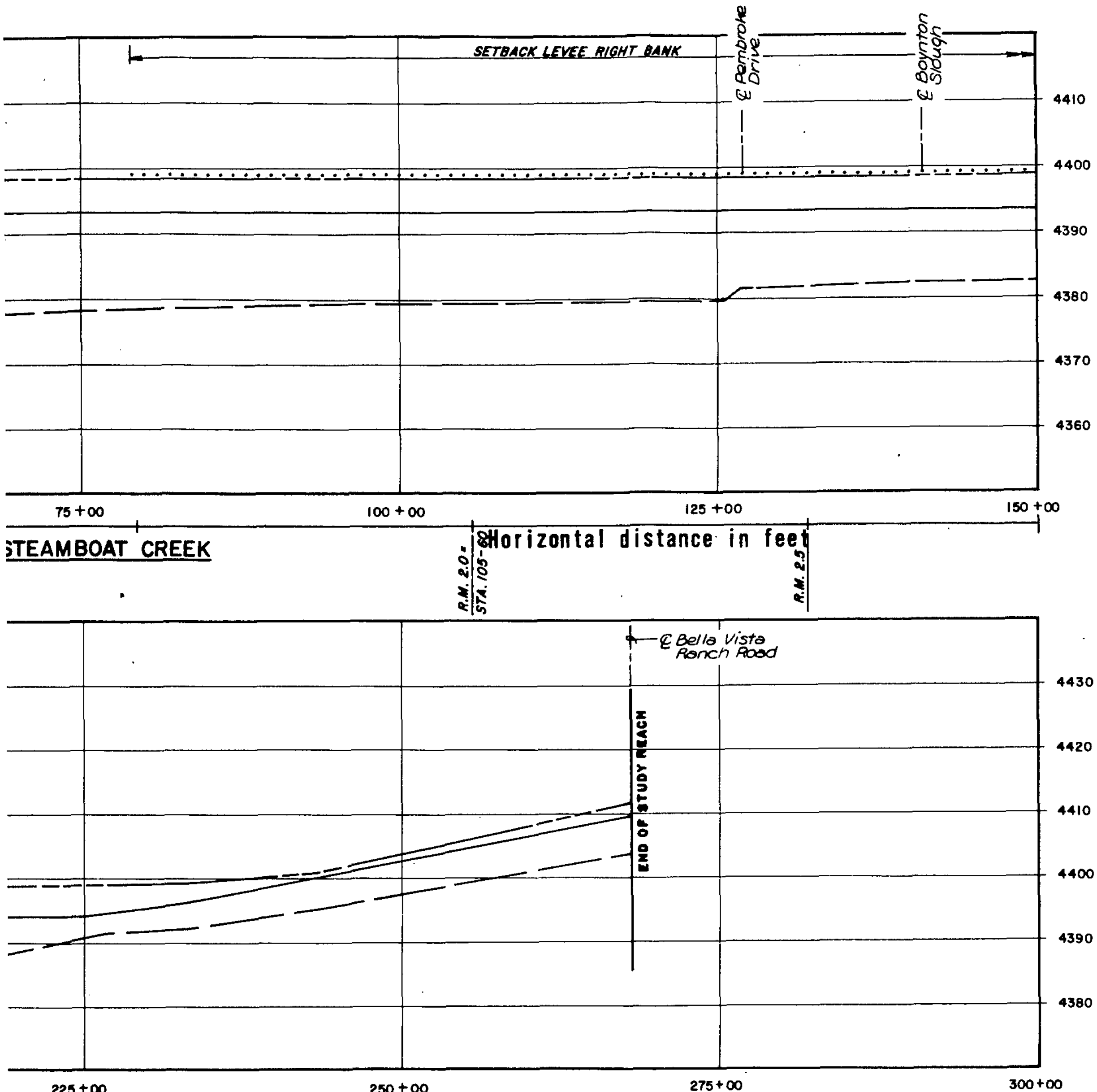
TRUCKEE RIVER
PROFILE
STA. 550+00 to STA. 660+00

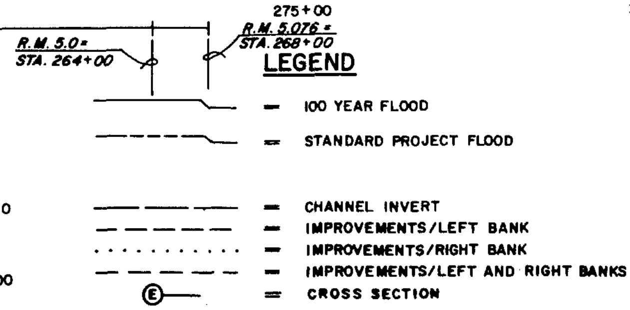
2

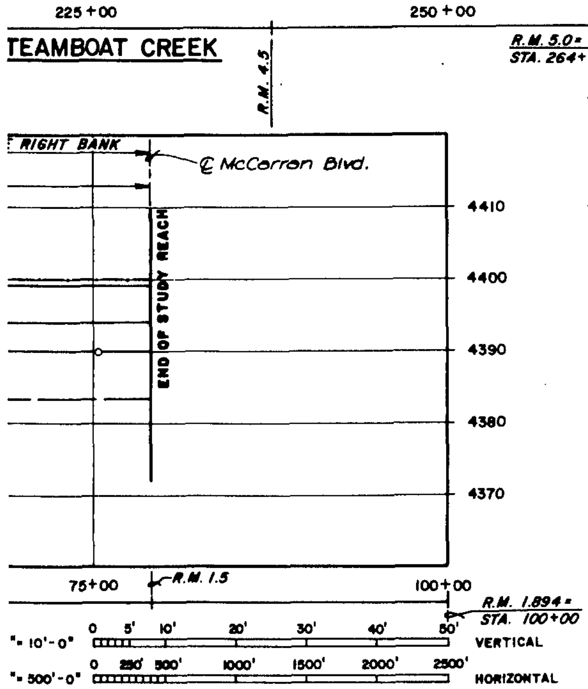
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

PLATE 10


℄ Truckee River
℄ Kimlick Lane
Elevation in feet above mean sea level
4410
4400
4390
4380
4370
4360
0+00
25+00
50+00
75+00
R.M. 0.00 = STA. 0+00
R.M. 0.5
R.M. 1.0 = STA. 52+80
STEAMBOAT
SETBACK LEVEE RIGHT BANK
STA. 202+40 OVERTOPPING DRAIN
SETBACK LEVEE LEFT BANK
4430
4420
4410
4400
4390
4380
150+00
175+00
200+00
225+00
R.M. 3.0 = STA. 158+40
℄ Steamboat Creek
R.M. 3.5
Horizontal distance in feet
R.M. 4.0 = STA. 211+20
STEAMBOAT
STA. 48+80 OVERTOPPING DRAIN
LEVEE LEFT BANK
LEVEE RIGHT BANK
4410
4400
4390
4380
4370
0+00
25+00
50+00
75+00
R.M. 1.0 = STA. 52+80.0
R.M. 0.00 = STA. 0+00
Horizontal distance in feet
BOYNTON SLOUGH
SCALE: 1" = 10'-0"
SCALE: 1" = 500'-0"







2

TRUCKEE MEADOWS INVESTIGATION
RENO-SPARKS METROPOLITAN AREA, NEVADA

PROFILE
STEAMBOAT CREEK / BOYNTON SLOUGH

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

PLATE 11

Section C

Geotechnical Exploration

SECTION C

GEOTECHNICAL EXPLORATION

TRUCKEE MEADOWS INVESTIGATION

RENO-SPARKS METROPOLITAN AREA

NEVADA

LEEDS, HILL AND JEWETT, INC.
1275 Market Street
San Francisco, CA 94103

MAY, 1982

SECTION C
GEOTECHNICAL EXPLORATION

TRUCKEE MEADOWS INVESTIGATION
RENO-SPARKS METROPOLITAN AREA
NEVADA

NOTE: Appendices A and B referred to in the test are not included in the Documentation Report. These Appendices are available at the Sacramento District Office.

SECTION 1

INTRODUCTION

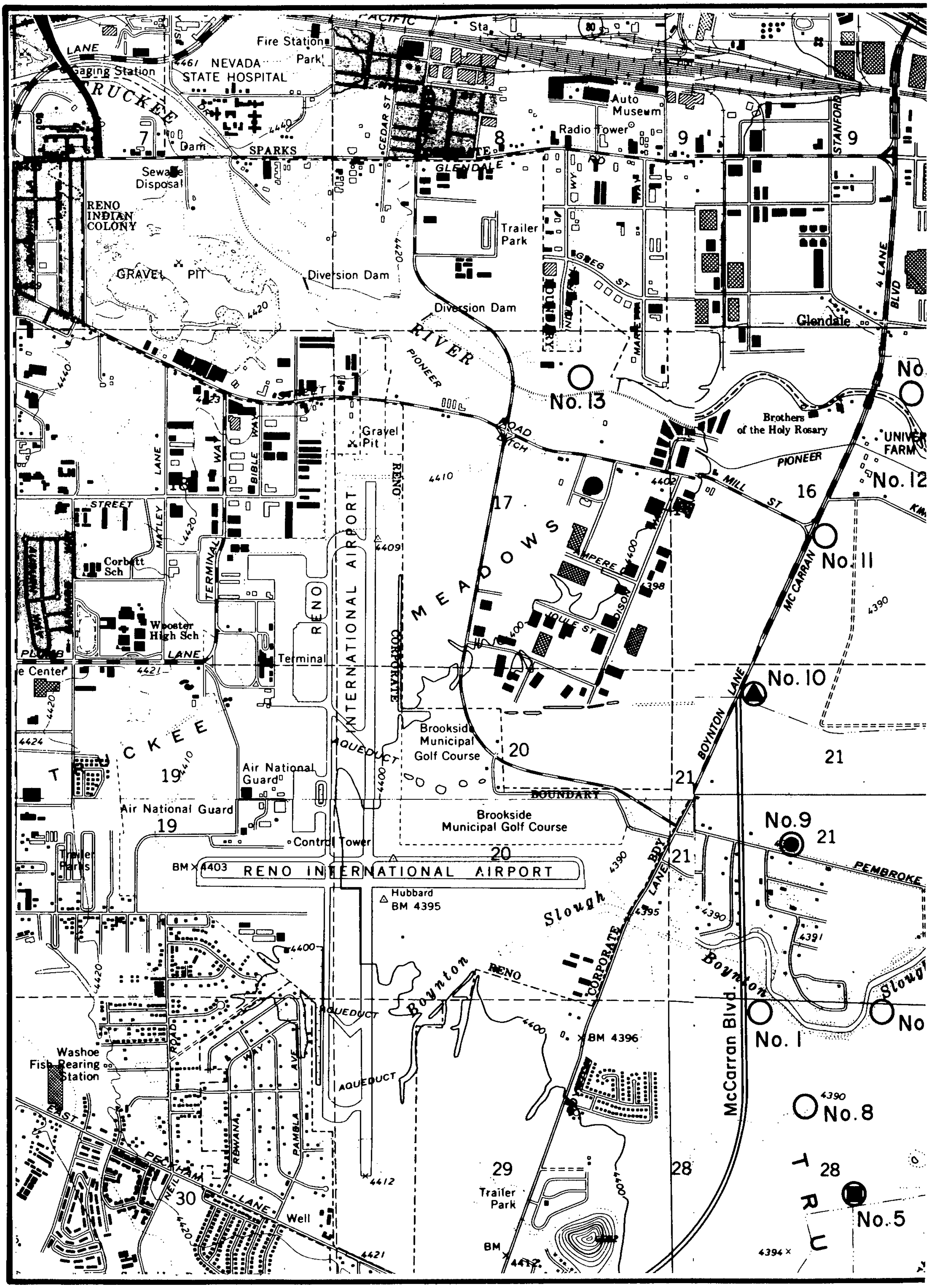
a. Scope of Work

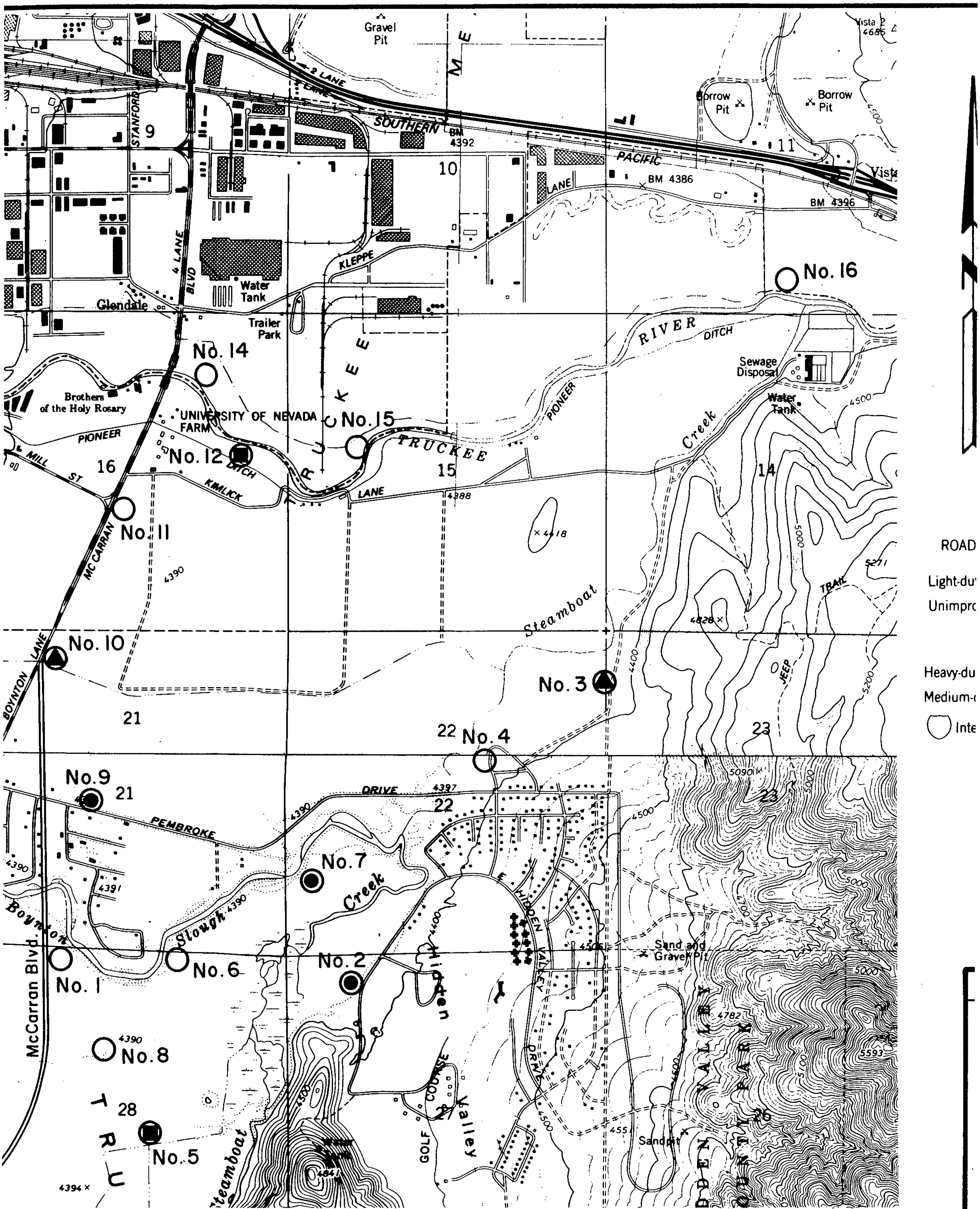
(1) The Truckee Meadows Investigation was authorized by Congress to determine the feasibility of providing flood protection for the Reno-Sparks Metropolitan Area. As part of the Truckee Meadows project, the Corps of Engineers, Sacramento District, has proposed the construction of a system of levees at the east end of the previously proposed Truckee River channel improvement. Leeds, Hill and Jewett, Inc. was authorized to perform subsurface geotechnical explorations, sampling, and laboratory testing of soils encountered along the proposed levee alignment. This work was performed in accordance with Work Order No. 4, Contract DACW05-81-0038. Specifically, the work consisted of obtaining right-of-entry permits from landowners, auger-drilling of 16 boreholes, each to a nominal depth of 20 feet, obtaining a relatively continuous record of Standard Penetration Test blow counts for each hole, logging each borehole, and obtaining disturbed and undisturbed samples of the soil encountered in the boreholes for compaction and laboratory testing. The locations of the boreholes are shown on Figure 1 and the borehole logs are contained in Appendix A.

(2) With the Corps of Engineers' approval, several modifications were made to the originally specified Scope of Work prior to the performance of that work. These modifications are discussed below.

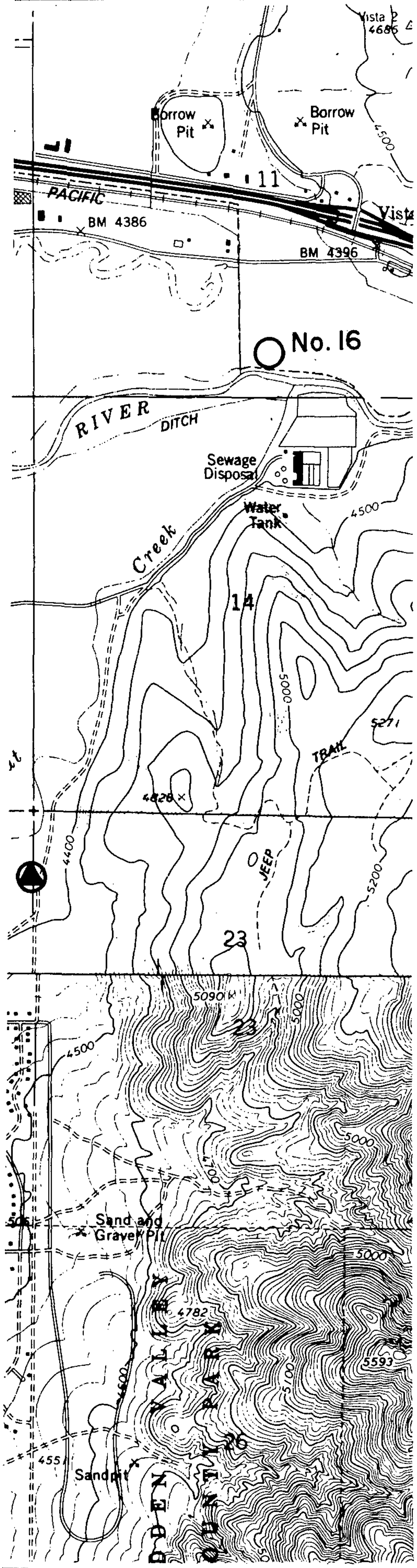
(3) The original Scope of Work specified that 19 boreholes were to be auger-drilled in the study area. However, due to difficulties associated with obtaining right-of-entry permits, only 16 holes were actually drilled.

(4) In the original Scope of Work, it was specified that eight undisturbed soil samples were to be obtained from four of the boreholes for the determination of the moisture content, specific gravity, Atterberg limits, gradation, and shear strength or consolidation characteristics of the soil, and that disturbed soil samples were to be obtained from the remaining boreholes for the determination of the moisture content, specific gravity, Atterberg limits and gradation. Instead, 13 undisturbed soil samples were obtained from nine of the boreholes and were used for the determination of the natural moisture content, in situ density, Atterberg limits, gradation, and shear strength or consolidation characteristics of the soil. Disturbed samples taken from six of the remaining seven holes were used for specific gravity, Atterberg limits, and gradation tests. The additional undisturbed samples were obtained primarily


PACIFIC
Sta
Fire Station
Park
NEVADA STATE HOSPITAL
TRUCKEE
Gaging Station
LANE
Dam
SPARKS
Sewage Disposal
RENO INDIAN COLONY
GRAVEL PIT
Diversion Dam
Diversion Dam
RIVER
PIONEER
CEDAR ST
GLENDALE
Auto Museum
Radio Tower
Trailer Park
GREG ST
STANFORD
4 LANE BLVD
Glendale
No. 13
Brothers of the Holy Rosary
UNIVER FARM
PIONEER
MILL ST
No. 12
No. 11
No. 10
No. 9
No. 1
No. 8
No. 5
MC CARRAN
BOYNTON LANE
McCarran Blvd.
PEMBROKE
STREET
MATLEY
Corbett Sch
Wooster High Sch
PLUMB
LANE
TERMINAL
BIBLE
Gravel Pit
RENO
Terminal
INTERNATIONAL AIRPORT
RENO
CORPORATE
MEADOWS
AMPERE
JOULE ST
DITCH
Brookside Municipal Golf Course
BOUNDARY
Brookside Municipal Golf Course
TRUCKEE
Air National Guard
Air National Guard
Control Tower
Trailer Parks
RENO INTERNATIONAL AIRPORT
BM 4403
Hubbard BM 4395
Slough
Boynton
Boynton
Slough
CORPORATE BDY LANE
AQUEDUCT
AQUEDUCT
AQUEDUCT
RENO
BM 4396
Washoe Fish Rearing Station
ROAD
WAY
AVE
REWANA
PAMBLA
EAST
PECKHAM
LANE
NEIL
Well
Trailer Park
BM
TRU
7
8
9
9
16
17
19
19
20
20
21
21
21
21
28
28
29
30
4410
4409
4400
4390
4391
4394
4412
4421
4424
4420
4440



Gravel Pit
Borrow Pit
Borrow Pit
Vista
4686
SOUTHERN
PACIFIC
BM 4392
BM 4386
BM 4396
2 LANE
STANFORD
9
10
11
LANE
KLEPPE
4 LANE BLVD
Water Tank
Glendale
Trailer Park
No. 16
RIVER
DITCH
Sewage Disposal
Water Tank
No. 14
Brothers of the Holy Rosary
UNIVERSITY OF NEVADA FARM
No. 15
PIONEER
TRUCKEE
Creek
No. 12
DITCH
MILL ST
KIMLICK
LANE
16
15
14
4388
No. 11
MC CARRAN
4390
5000
5271
TRAIL
Steamboat
4828
No. 10
BOYNTON LANE
JEEP
5200
No. 3
4400
21
22
No. 4
23
No. 9
21
DRIVE
4397
PEMBROKE
22
5090
23
4500
No. 7
Creek
Slough
Boynton
4391
4390
HIDDEN VALLEY
Sand and Gravel Pit
No. 2
No. 1
No. 6
McCarran Blvd.
Hidden Valley
4782
VALLEY
PARK
5593
No. 8
4390
28
GOLF COURSE
DRIVE
No. 5
Steamboat
4394
4841
Sandpit
ROAD
Light-du
Unimpro
Heavy-du
Medium-
Inte



EXPLANATION

- Auger Borings
- Auger Borings and Compaction Samples
- Auger Borings and Undisturbed Samples for Shear Strength Tests
- Auger Borings and Undisturbed Samples for Consolidation Tests

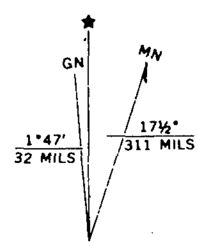
Note:

Topographic base from portions of U.S.G.S. Quadrangle 7.5 minute series, Reno, Vista, Mt. Rose NE, and Steamboat, Nevada.

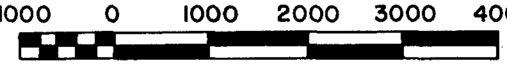
ROAD CLASSIFICATION

Light-duty
Unimproved dirt
State Route
Heavy-duty
Medium-duty
Interstate Route
U. S. Route

QUADRANGLE LOCATION



UTM GRID AND 1974 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET



Truckee Meadows Investigation

Corps of Engineers • Sacramento, CA.

LOCATION MAP

Leeds, Hill & Jewett, Inc.
May 1982

3

Figure 1

for the determination of the in situ soil density and moisture content, since these two properties are necessary for most soil mechanics analyses.

(5) The original Scope of Work specified that one specific gravity determination was to be made per borehole. However, only six specific gravity tests were performed since it was mutually agreed that the usefulness of the value of the specific gravity of a soil in a soil mechanics analysis is extremely limited relative to the usefulness of the density and moisture content. Thus it was considered prudent to obtain additional undisturbed soil samples for density and moisture content determinations at the expense of specific gravity determinations.

(6) Organic content determinations were made for two samples of a high plasticity clay which contained a significant fraction (approximately 50 percent by volume) of partially decayed vegetation. The performance of these tests was not specified in the Scope of Work.

(7) Undisturbed soil samples for triaxial and direct shear testing were obtained from boreholes Nos. 2 and 9, rather than the specified boreholes, because right-of-entry permits could not be obtained for drilling the specified boreholes.

(8) Undistrubed samples for consolidation testing were obtained from borehole Nos. 8 and 15 because the soft clay encountered in these boreholes was very similar to clay encountered in previously-drilled boreholes and, hence, was considered to be a significant soil type in the study area.

(9) Soil for compaction testing was obtained from borehole Nos. 5 and 14 rather than the specified boreholes because a right-of-entry permit could not be obtained from one of the specified boreholes and only a medium-plastic clayey material was encountered in the second specified borehole.

(10) Borehole No. 7 and borehole Nos. 9 through 14 were not drilled to a depth of 20 feet because gravel was encountered, rendering both disturbed and undisturbed sampling impossible.

b. Method of Investigation

(1) Drilling Equipment. The boreholes were drilled between March 4 and March 10, 1982 by P.C. Exploration, Inc., of Roseville, California, using a 6-inch O.D. hollow-stem auger powered by a Mobile truck-mounted drill rig. For drilling, a 3-inch diameter drill bit was inserted through the hollow stem of the auger. To perform a Standard Penetration Test (SPT) or to obtain an un-

disturbed soil sample, the bit was withdrawn and replaced with a 1-1/2 inch I.D. split spoon sampler for the SPT, or a 3-inch O.D., 2-7/8 inch I.D. Shelby tube for undisturbed sampling.

(2) Standard Penetration Tests. Standard Penetration Tests were performed in accordance with ASTM Standard D1586-67. The tests consisted of dropping a 140-pound hammer a distance of 30 inches to drive a 1-1/2-inch I.D. split spoon sampler into the soil at the bottom of the borehole. The number of blows required to drive the sampler a specified depth is the SPT blow count. One 18-inch SPT was performed approximately every 24 inches of borehole except in intervals where undisturbed (Shelby tube) samples were taken or where gravel was encountered. The boreholes were logged from the soil retained in the split spoon sampler after an SPT. The results of the SPT's are discussed in more detail in Section 2 of this report.

(3) Undisturbed Soil Samples. Undisturbed soil samples were obtained by pushing a 3-inch O.D., 2-7/8 inch I.D. Shelby tube into the undisturbed soil at the bottom of a borehole. The Shelby tubes were 36 inches long and up to 34 inches of soil were recovered per tube. Undisturbed soil samples were obtained for laboratory determinations of the in situ density and moisture content, the drained and undrained shear strength parameters, and the consolidation characteristics.

(4) Compaction Tests. Compaction tests were performed in the field on the non-plastic silty sand material which was present in most of the boreholes. The compaction tests were performed in accordance with ASTM Standards D698-70, Method A and D1557-70, Method B. Standard D698-70 is commonly referred to as the Standard Proctor compaction test. It consists of dropping a 5.5-pound hammer a distance of 12 inches onto moist soil contained in a 4-inch diameter mold. Standard D1557-70 is often referred to as the Modified Proctor compaction test and it consists of dropping a 10-pound hammer a distance of 18 inches onto moist soil contained in a 6-inch diameter mold. The moisture contents of samples of the compacted soil were determined in the laboratory. The results of the compaction tests are discussed in more detail in Section 3 of this report.

SECTION 2

SOIL EXPLORATION

a. Soil Classification

(1) Six soil types were identified in the borings drilled along the proposed Truckee Meadows levee alignment. Each of these soil types was encountered at least once in most of the boreholes. The soil types described below represent 92 percent of the soil encountered by drilling, the remaining 8 percent being augered and not recovered.

(2) The predominant soil type is a non-plastic silty fine- to medium-grained sand or clayey silty fine- to medium-grained sand (Unified Soil Classification Symbol: SM-SC). This soil varies in color from gray to brown and, in general, is loose. The fines content varies from 5 to 40 percent. Approximately 20 percent of the soil recovered from the borings was this silty sand.

(3) A second soil type is a dark gray to dark brown, loose, fine- to coarse-grained sand (SP). The coarse sand grains are sub-angular in shape. In some of the split spoon samples recovered, up to approximately 5 percent of the fine- and medium-sized sand grains were flat, angular flakes of mica. Approximately 16 percent of the soil recovered from the boreholes was this loose sand.

(4) A third soil type encountered in the borings is a highly plastic clay (CH). In general, the clay is almost uniformly gray in color and has a uniformly soft consistency. However, in some intervals, the clay is dark gray to black in color and contains as much as 50 percent organic material in the form of partially decayed broadleaf grass. This soil comprises approximately 15 percent of the material recovered from the boreholes.

(5) A grayish-brown to dark brown sandy silt of low plasticity (ML) also made up approximately 15 percent of the soil recovered from the boreholes. In general, this soil has a firm consistency.

(6) A fifth soil type encountered in the borings is an inorganic silty clay or fine sandy silty clay of low to medium plasticity (CL). This soil varies from dark gray to grayish-brown to dark brown in color and from firm to stiff in consistency. Approximately 15 percent of the soil recovered from the boreholes was this silty clay.

(7) The sixth soil type encountered is a silty sandy gravel (GW). The gravel is rounded and varies in size from 3/4 inch to 6 inches across. Where the gravel occurred below the water table, the

sides of the borehole in the gravel interval usually collapsed upon withdrawal of the auger, indicating that the density of the gravel is relatively low. Approximately 11 percent of the soil recovered during boring was gravel.

b. Soil Stratification

(1) The six soil types identified above as being common along the proposed levee alignment generally vary from borehole to borehole in the sequence, predominance, depth and thickness of their occurrence. Notable exceptions to this trend are the presence of the decayed vegetation in the highly plastic clay and the occurrence of the silty sandy gravel. The decayed vegetation is present between the depths of approximately 8 and 11 feet in borehole Nos. 9, 10, and 11 in the vicinity of the junction of McCarran Boulevard and Boynton Lane, while the gravelly material is encountered only in boreholes relatively close to the Truckee River, namely borehole Nos. 9 through 14, and at depths in the boreholes approximately level with the height of the riverbed.

(2) Regardless of their occurrence, the sands and silty sands are consistently loose and the clays appear to be normally consolidated. The contacts between all soil types, as they appeared in the split spoon samples, are planar and horizontal.

(3) The looseness of the sandy material and the softness of the normally consolidated clays are indications that the material was deposited hydraulically. The planar horizontal contacts indicate that the water was probably relatively still and the abruptness of the change in the nature of the soil at some of the contacts probably reflects a relatively abrupt change in the environment or mode of transportation and deposition of the soil. The variation in stratigraphy from borehole to borehole may be an indication that the soil was deposited at the bottom of a relatively large still body of water, such as a lake, because the gradation of the soil deposited at the bottom of a lake tends to change (i.e., become finer) toward the center of the lake and away from the mouths of streams that transport the material to the lake. Thus, at any given depth below the bottom of a lake, the soil gradation is a function of the location of the soil sample relative to the shore at the time of its deposition. The partially decayed broadleaf grasses which were present in borehole Nos. 9, 10, and 11 are indicative of a wet, probably marshy, environment. The rounded gravels which were encountered in the boreholes located near the present-day Truckee River were probably transported by the river. Borehole No. 15 was located on approximately eight feet of artificial fill about 20 to 25 feet above the bed of the Truckee River, hence does not show the variations in the nature of the soil as the other holes located close to the Truckee River.

c. Standard Penetration Tests

(1) One 18-inch Standard Penetration Test (SPT) was performed approximately every 24 inches of borehole except in intervals where undisturbed samples were taken or where gravel was encountered. The blow counts were recorded for every six inches of penetration. Of the six predominant soil types encountered in the boreholes, the SPT results are considered to be reasonable only for the sand located above the water table, the soft clay, and the silty material. In the loose sands located below the water table, the impact of the split spoon sampler probably liquefied the initial approximately 12 inches of soil, then compacted the final six inches so that the test probably yielded blow counts that are initially too low and finally too high. In the gravelly material, the gravel tended to lodge in the tip of the sampler, thus giving the sampler the effect of a compactor rather than a penetrometer.

d. Groundwater Levels

(1) In all of the boreholes except Nos. 15 and 16, the groundwater table was located approximately 5 to 7 feet below the surface of the ground. No groundwater was apparent in either borehole No. 15 or borehole No. 16, although the soil in those holes became wetter with depth.

SECTION 3

LABORATORY TESTING PROGRAM

a. General

(1) As discussed in Section 2, six soil types were identified in the borings drilled along the proposed Truckee Meadows levee alignment. However, samples for laboratory testing were recovered for only four of these soil types, namely the silty sand, the plastic clay, the sandy silt and the sandy silty clay.

(2) Laboratory testing was performed on undisturbed and disturbed samples of the soils for the purposes of classifying the soil materials and establishing appropriate values for their engineering properties. The testing program included sieve analyses for determination of the grain size distribution, and one-dimensional consolidation tests for determination of the consolidation characteristics, Atterberg limits, natural water content, in situ dry density, organic content, and specific gravity determinations. Consolidated drained direct shear tests and unconsolidated undrained and consolidated undrained (with pore pressure measurements) triaxial tests were also performed to determine the strength of some of the soils. The laboratory tests were performed by Harding Lawson Associates, Reno, in accordance with the standards of the American Society for Testing and Materials (ASTM). The results of the laboratory testing program are given in Appendix B and summarized in the following paragraphs.

b. Clayey Silty Sand

(1) Split spoon samples of the clayey silty sand were used for sieve analyses and for determination of the specific gravity and Atterberg limits. Undisturbed samples of the material were used for determinations of the natural moisture content and in situ density and for shear strength testing. The fines content of nine samples of the clayey silty sand varied from 8 to 49 percent, with an average value of 31 percent and a mean value of 28 percent. The range of specific gravity values obtained was 2.58 to 2.68, with an average of 2.63.

(2) Atterberg limits determinations for the three clayey silty sand samples with fines contents of 49 and 48 percent yielded liquid limits of 31, 34 and 52 percent, and plasticity indices of 7, 10 and 25 percent, confirming the presence of some clay in these samples. The natural water content of three samples of the clayey silty sand were 31.9, 37.9, and 43.6 percent and their respective dry densities were 80.1, 69.8 and 73.4 pcf. Such low dry densities are typical of very loose inorganic silts (Lambe and Whitman, 1969).

(3) Shear strength tests were performed on samples of silty sand containing up to 45 percent fines. The tests performed included consolidated drained direct shear tests (DS/CD), consolidated undrained triaxial shear tests (with pore pressure measurements; TX/CU/P) and unconsolidated undrained triaxial shear tests (TX/UU). The direct shear tests were performed with consolidation (i.e., normal) pressures of 0.5, 1.0 and 2.0 tsf (tons per square foot) and the triaxial shear tests were performed with consolidation (i.e., confining) pressures of 0.5 and 1.0 tsf. The direct shear tests yielded an effective (i.e., drained) cohesion value of 0.5 tsf and an effective angle of friction of 45 degrees, while the TX/CU/P tests yielded an effective cohesion of 0.3 tsf and an effective angle of friction of 27 degrees. Undrained shear strength parameters obtained from the TX/CU/P test were a cohesion of 0.6 and an angle of friction of 8 degrees. The TX/UU tests yielded a cohesion of 0.4 and an angle of friction of 14 degrees. The relatively low undrained friction angles and the relatively high undrained cohesion values indicate that the triaxial test specimens contained a high proportion of clayey fines.

c. Plastic Clay

(1) Tests were performed on two split spoon samples and two undisturbed samples of the plastic clay for the determination of the gradation, Atterberg limits, natural moisture content, in situ density, organic content and triaxial shear strength. The gradation and plasticity analyses show that the clay has a fines content of 94 percent, a liquid limit of 106 percent and a plasticity index of 69 percent. The natural moisture content of the clay is approximately 40 percent and the corresponding dry density is 69.9 pcf.

(2) Three triaxial shear tests were performed under consolidated undrained conditions with pore pressure measurements. The consolidation pressures were 0.5, 1.0 and 2.0 tsf. These tests yielded effective (i.e., drained) cohesion and angle of friction values of 0.2 tsf and 29 degrees, respectively, and undrained cohesion and angle of friction values of 0.2 tsf and 12 degrees.

(3) The organic content of the clay was determined by the ignition method to be 0.4 percent by weight. The borehole logs (Appendix A) indicate that as much as 50 percent of the volume of some plastic clay samples consisted of organic materials.

d. Sandy Silt

(1) Undisturbed and split spoon samples of the sandy silt were used for sieve analyses and for determination of the specific gravity, Atterberg limits, natural moisture content, in situ density and consolidation characteristics.

(2) The gradation and plasticity analyses show that the sandy silt has a fines content of 65 to 80 percent, an average liquid limit of 40 percent and an average plasticity index of 10 percent. The natural moisture content of the sandy silt ranges from 38 to 52 percent, with an average and a mean value of 44 percent, and the corresponding dry densities range from 68.1 to 76.7 pcf, with an average and a mean value of 73 pcf. These in situ densities are similar to those obtained for the silty sand samples and are typical of very loose inorganic silts. Two specific gravity tests yielded values of 2.54 and 2.58.

(3) The results of a consolidation test on one sample of the sandy silt confirms that the soil is normally consolidated and has a compression index, c_c, of 0.35.

e. Sandy Silty Clay

(1) Three undisturbed samples of the sandy silty clay were used to determine the gradation, Atterberg limits, natural water content, in situ dry density, triaxial shear strength and consolidation characteristics. The gradation and plasticity analyses show that the sandy silty clay has an average fines content of 67 percent, an average liquid limit of 46 percent and an average plasticity index of 21 percent. The natural moisture content of this material is approximately 29 percent and the corresponding dry density is 88 pcf.

(2) Triaxial shear tests performed on samples of the sandy silty clay included both consolidated undrained tests (with pore pressure measurements; TX/CU/P) and unconsolidated undrained tests (TX/UU). The TX/CU/P tests yielded an effective (i.e., drained) cohesion value of 0.25 tsf, an effective angle of friction of 32 degrees, a total cohesion value of 0.2 tsf and a total angle of friction of 31 degrees. The results of the unconsolidated, undrained triaxial tests yielded a cohesion value of 0.2 tsf and an angle of friction of 13 degrees. The results of the TX/CU/P tests are relatively high for a clayey material with an average liquid limit of 46 percent and may indicate that the TX/CU/P test specimens contained a high proportion of sand.

f. Summary of Test Results

(1) Laboratory Tests. Table 3-1 summarizes the results of the laboratory testing program on samples of the soils encountered in the borings drilled along the proposed Truckee Meadows levee alignment. The laboratory data in Appendix B are arranged in the order of samples listed in Table 3.1.

TABLE 3-1

AVERAGE VALUES FOR SOIL PROPERTIES

Soil Type	Clayey Silty Sand	Plastic Clay	Sandy Silt	Sandy, Silty Clay
Sample Nos.*	S5-1, S8-2 S12-1, S14-1 S15-1, S16-1 U2-1, U2-2, U7-2, U9-3	S10-1, S16-2 U4-1, U7-1	S4-1, S15-2 U1-1, U3-1, U6-1	U9-1, U10-1 U11-1
Natural Water Content (%)	37.8	40	44	29
In Situ Dry Density (pcf)	74.4	69.6	73	88
Liquid Limit (%)	39	106	40	46
Plasticity Index (%)	14	69	10	21
% Fines	31	94	72	67
Specific Gravity	2.63	-	2.56	-
Total Consolidated Shear Strength **	$c = 0.6$ $\phi = 8$	$c = 0.2$ $\phi = 12$	-	$c = 0.2$ $\phi = 31$
Effective Consolidated Shear Strength (Triaxial Tests) **	$c' = 0.3$ $\phi' = 27$	$c' = 0.2$ $\phi' = 29$	-	$c' = 0.2$ $\phi' = 32$
Total Unconsolidated Shear Strength **	$c = 0.4$ $\phi = 14$			$c = 0.2$ $\phi = 13$
Consolidation Characteristics			$C_c = 0.35$	$C^c = 0.28$

* S = Split Spoon Sample
U = Undisturbed (Shelby tube sample)

** c, c' = cohesion (tsf)
ϕ, ϕ' = angle of friction (degrees)

APPENDIX A

DRILLING LOGS

<u>REFERENCE</u>

Lambe, T.W. and Whitman, R.V. (1969). <u>Soil Mechanics</u>, John Wiley and Sons, Inc., New York, 553 pp.

(2) Compaction Tests. As discussed in Section 1, Standard and Modified Proctor compaction tests were performed in the field on the silty sand soil. The results of the compaction tests are included in Appendix B. The C1 and CM1 series of compaction tests were performed on a soil containing approximately 11 percent fines and the C2 and CM2 series soil contained approximately 41 percent fines. This difference in fines content was definitely reflected in the results of the compaction tests in that the C1 and CM1 series of tests yielded greater dry densities at lower optimum water contents than the corresponding C2 and Cm2 test series. The results of the compaction tests are summarized in Table 3-2.

TABLE 3-2

SUMMARY OF COMPACTION TESTS

Test Series	1		2	
Test Type	Standard (C1)	Modified (CM1)	Standard (C2)	Modified (CM2)
Max. dry density (pcf)	121	124 (approx)	105	115 (approx)
Opt. Moisture content (%)	17.5	15 (approx)	20.5	17 (approx)

Section D

Soils and Geology Office Study

SECTION D

SOILS AND GEOLOGY OFFICE STUDY

TRUCKEE MEADOWS INVESTIGATION

September 1981

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SOILD AND GEOLOGY OFFICE STUDY
TRUCKEE MEADOWS INVESTIGATION

September 1981

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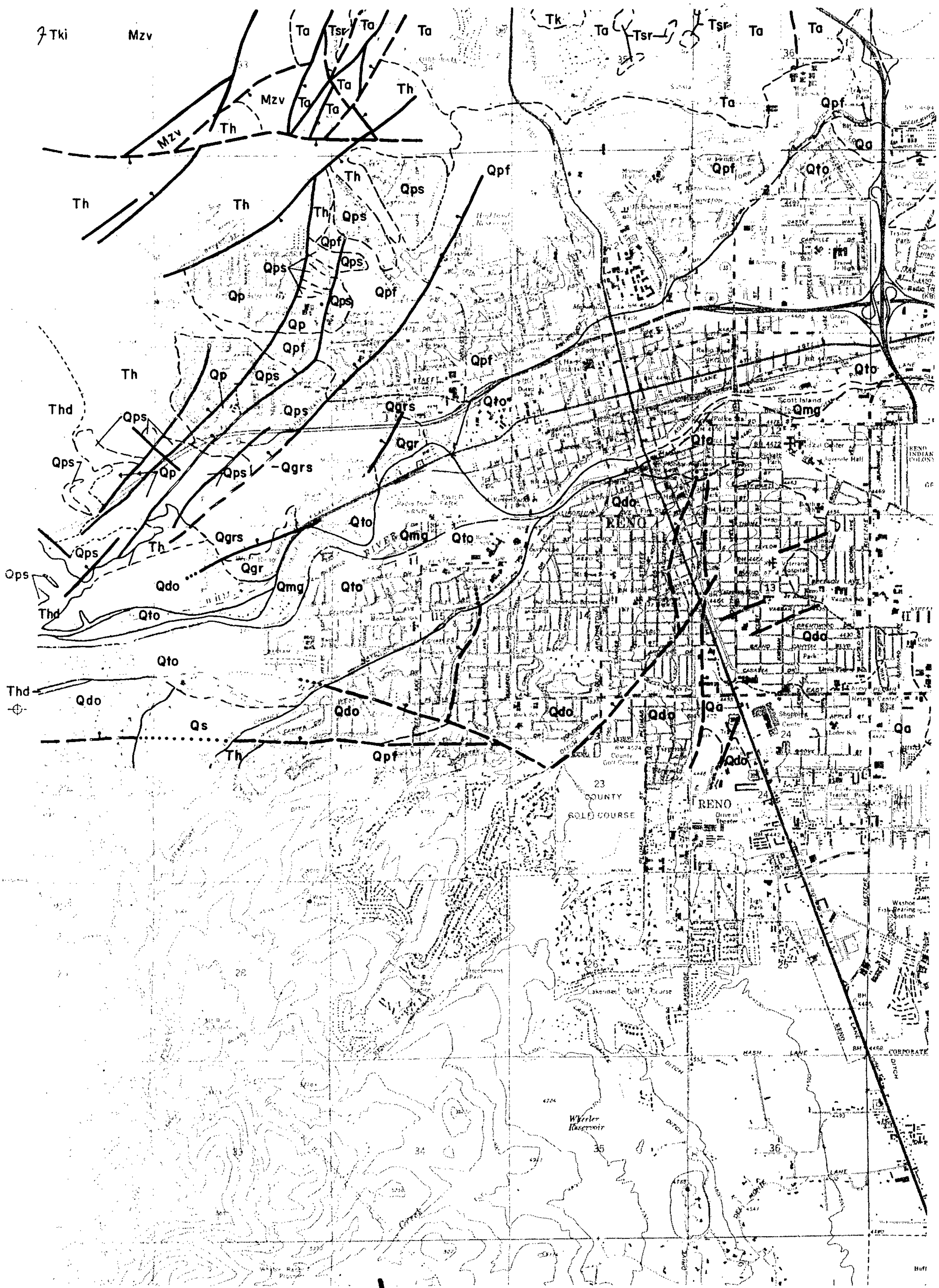
NOTE: Appendix A containing the Location Maps, Logs of Soil Borings and Test Data is not included in the Documentation Report. This appendix is available at the Sacramento District Office.



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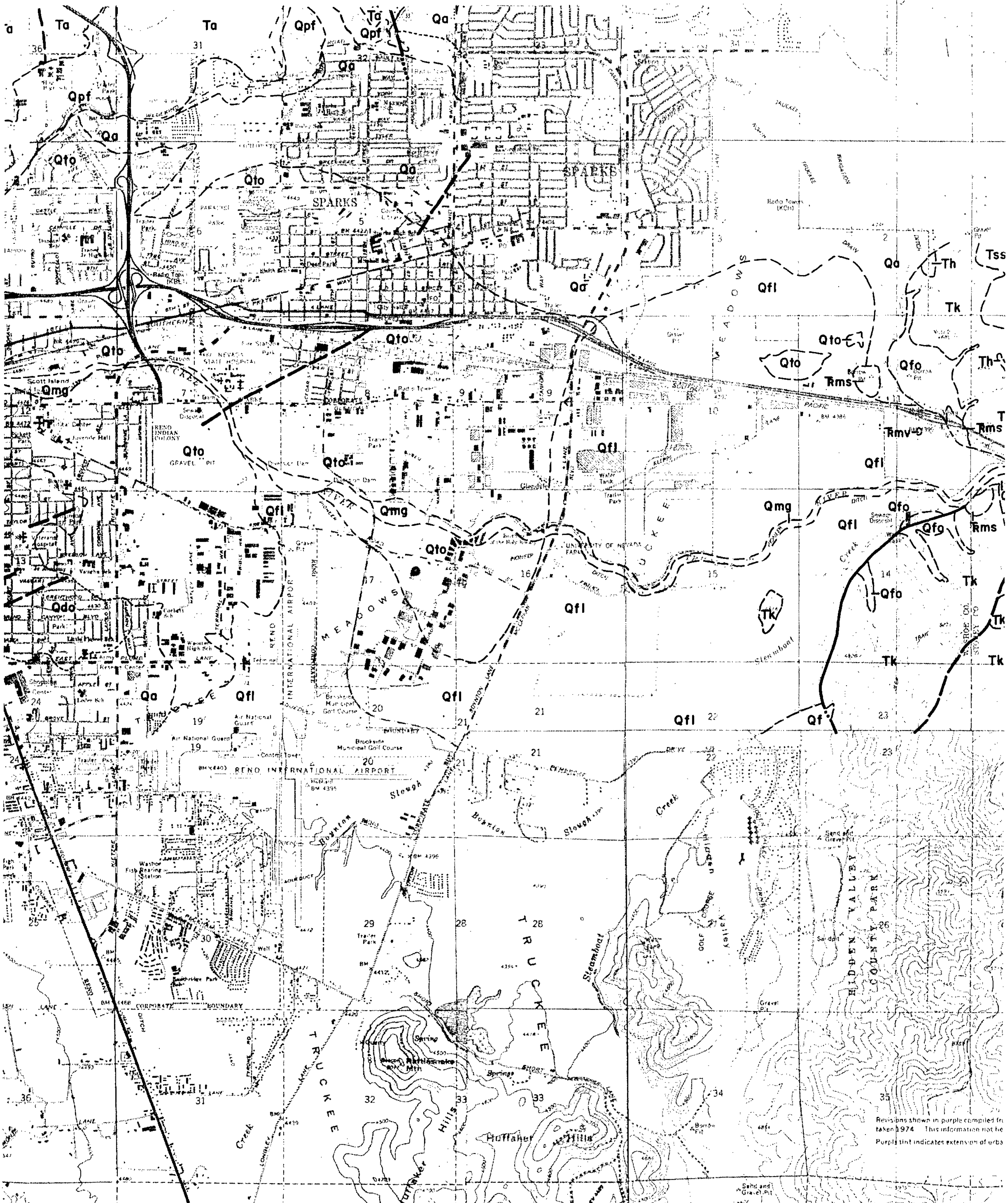
Scott Island
RENO INDIAN COLONY
COUNTY GOLF COURSE
Wheeler Reservoir
CORPORATE



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RENO INDIAN COLONY
GRAVEL PIT
Scott Island
Juvenile Hall
Veterans Hospital
Sewage Disposal
Radio Tower
Trailer Park
Glendale
UNIVERSITY OF NEVADA FARM
MEADOWS
TRUCKEE
RENO INTERNATIONAL AIRPORT
Air National Guard
Brookside Municipal Golf Course
Boynton Slough
Steamboat Creek
Rattlesnake Mtn
Huffaker Hills
HIDDEN VALLEY COUNTY PARK
Washoe Fish Rearing Station
Sand and Gravel Pit
Borrow Pit
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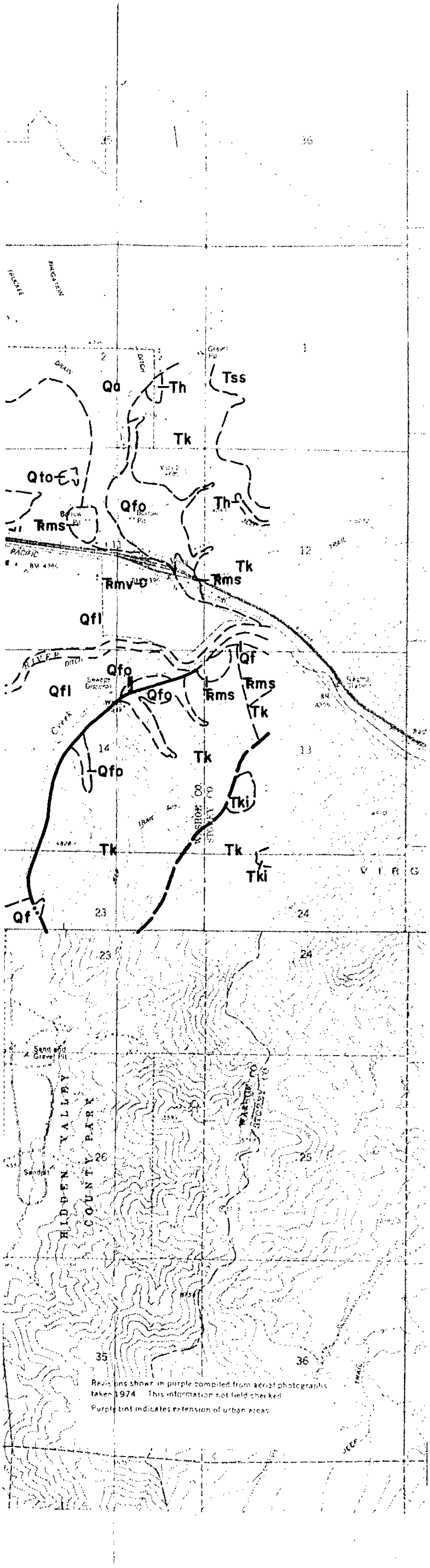
taken 1974 This information not he
Purple tint indicates extension of urba



EXPLANATION OF SYMBOLS

QUATERNARY

Qmg — MAINSTREAM GRAVEL. Sandy cobble gravel confined to the present Truckee River floodplain.

Qfl — FLOODPLAIN AND LAKE DEPOSITS. Thin sheet of medium- to thin-bedded clayey silt and sand. Contains discontinuous layers of silt and peat.

Qa — ALLUVIUM. Poorly sorted clayey to silty gravelly sand, poorly bedded to unbedded.

Qf — ALLUVIAL FAN DEPOSITS. Sandy gravel. Younger than but similar to Qfo. Derived from the Virginia Range.

Qfo — OLD ALLUVIAL FAN DEPOSITS. Sandy pebble and cobble gravel with considerable variations in composition. Consists of volcanic materials derived from the Virginia Range.

Qp — PEDIMENT DEPOSITS. Thin sheets of gravelly silt and silty clay. Weakly weathered.

Qto/Qs — TAHOE OUTWASH. Qto: Boulder to cobble gravel, sandy gravel, and gravelly sand. Contains giant boulders. Rock clasts are rounded to subrounded, and in decreasing order of abundance are granitic, volcanic, and metamorphic. Qs: Sidestream deposits.

Qdo — DONNER LAKE OUTWASH. Deposits similar to Tahoe outwash except weathered to depths of four feet or more.

Qps — PEDIMENT AND STREAM GRAVEL. Thin deposits of sandy to clayey, cobble to small boulder gravel. Moderately to deeply weathered. Chalk Bluff area - contains numerous large, rounded to highly rounded cobbles and boulders of basalt and granitic rock. Peavine Creek area - contains many locally derived white to yellowish white, silicified andesite fragments.

Qgr/Qgrs — GRAVEL OF RENO. Qgr: Moderately well-sorted sandy cobble gravel. Slightly cemented. Qgrs: Weakly-bedded deposits of coarse sand containing scattered small cobbles and thin cobble layers.

Qpf — ALLUVIAL FAN DEPOSITS OF PEAVINE MOUNTAIN. Poorly sorted, pale yellowish to reddish brown, montmorillonitic, gravelly to sandy and clayey silt. White silicified andesite fragments common. Black Springs area - pale orange-brown clayey and gravelly sand.

UNCONFORMITY

TERTIARY

Th/Thd — SANDSTONE OF HUNTER CREEK. Th: Pale brown to gray-brown and greenish gray, prominently bedded, interlayered siltstone, silty sandstone, and sandy conglomerate. Thd: White to yellowish white diatomite and diatomaceous sandstone.

Tk/Tki — KATE PEAK FORMATION. Tk: Gray, porphyritic, hornblende-biotite andesite flow containing phenocrysts of plagioclase, biotite, and hornblende. Tki: Intrusive rock lithologically similar to the flow.

Tsr — SILICIFIED ROCK. Silicified rock and breccia consisting almost entirely of fine-grained red-brown quartz, colored by iron-oxide. This unit is confined to areas of altered volcanic or granitic rocks.

Ta — ALTA FORMATION. Dark brown pyroxene andesite flows, flow breccia, and laharic breccia. Commonly altered to tan rock composed of quartz, sericite, and clay minerals or propylitized to gray-green rock containing chlorite, calcite, albite, epidote, and clay minerals.

Tss — SPANISH SPRINGS PEAK BASALTIC ANDESITE.

MESOZOIC

Mzv — PEAVINE SEQUENCE. Gray to gray-green metavolcanic rocks with subordinate amounts of metamorphosed epiclastic volcanic sedimentary rocks. The metavolcanic rocks include rhyolite flows and pyroclastics and dacite to andesite flows and laharic breccias. Where fresh, highly resistant to erosion and tends to form bold outcrops.

Rmv — TRIASSIC METAVOLCANIC ROCK.

Rms — TRIASSIC METASEDIMENTARY ROCK.

CONTACT. Long dash where approximately located; short dash where indefinite.

FAULT. Dashed where approximately located; dotted where concealed. Ball on downthrown side.

NOTES:

1. Topographic base from portions of U.S.G.S. Quadrangle 7.5 series, Reno, Vista, Mt. Rose NE, and Steamboat, Nevada.
2. The geology of the Reno quadrangle, by H.F. Bonham, Jr. and E.C. Bingler (1973) is from the Geologic Map in the Reno Folio, Nevada Bureau of Mines and Geology, Environmental Series (1976) and the geology of the Vista quadrangle is from a preliminary unpublished manuscript by N.B.M.G.
3. This map illustrates the distribution of bedrock and surficial deposits in the Reno quadrangle. The geologic mapping was done as a reconnaissance, thus the user should regard this map as preliminary.

ROAD CLASSIFICATION

Light-duty
Unimproved dirt
State Route
Heavy-duty
Medium-duty
Interstate Route
U.S. Route

SCALE 1:24 000

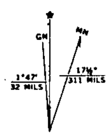
1 — 0 — 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETRE

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

QUADRANGLE LOCATION



UTM GRID AND 1974 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

RENO AND SPARKS, NEVADA

TRUCKEE MEADOWS INVESTIGATION

AREAL GEOLOGY

FIGURE 1

SOILS AND GEOLOGY OFFICE STUDY

TRUCKEE MEADOWS INVESTIGATIONS

1. Purpose. The purpose of this study is to develop Stage III Geotechnical Information for the Truckee Meadows Investigation, a channel modification project through the City of Reno, Nevada. This report is prepared in response to a request from Levees and Channels Section, (DF dated 7 July 1981).

2. Scope. This report summarizes geological and soils data obtained from a literature search and field reconnaissance in the Reno area. The report includes an assessment of local geological and foundation conditions along the Truckee River and adjacent areas. The availability of construction materials is discussed.

3. Regional Geology. Reno is located on the western edge of the Great Basin in an area that is transitional between the Basin and Range and the Sierra Nevada physiographic provinces. The Truckee River, in Reno and Sparks, flows eastward through the Truckee River valley and the northern portion of Truckee Meadows. Truckee Meadows is a structural basin bounded on the west by the Carson Range, on the east by the Virginia Range, on the south by Steamboat Hills, and on the north by the Peavine Mountain block (Bingler, 1975). The oldest rocks in the area are the structurally complex Mesozoic metavolcanic and metasedimentary rocks of the Peavine sequence that were intruded by granitic plutons (Nevada Bureau of Mines and Geology - NBMG - Reno Folio, Environmental Series, 1976). These older rocks are overlain by a thick sequence of Tertiary volcanic and epiclastic rocks consisting of lava flows, breccias, and tuffs. Large areas of the volcanics are hydrothermally altered. Miocene to late Pliocene age fluviatile and lacustrine sediments

were the initial deposits to accumulate in the downwarped Reno basin. These deposits, consisting of conglomerate, siltstone, sandstone, and diatomite are exposed along the margins of Truckee Meadows. According to Bingler (1975) three major categories of Quaternary deposits in Truckee Meadows represent a long-established pattern of basin sedimentation. These consist of: (1) Holocene to Recent Truckee River gravel and Pleistocene glacial outwash deposits, (2) Quaternary to Holocene complex alluvial fan deposits around the margins of Truckee Meadows, and (3) Holocene to Recent fine-grained floodplain and lake deposits throughout the central and eastern part of Truckee Meadows.

The geologic structure of the area was produced by faulting and warping that began by at least late Miocene time and continued into Holocene time. Quaternary faults are common and widespread in the area of the Mount Rose fan complex, northwest of Steamboat Hills, and northward through Reno. Nearly all are normal faults that display Pleistocene movement, but some cut Holocene deposits. Displacement of these faults ranges from a few feet up to about 50 feet. The higher scarps are present along the west edge of Virginia Lake, southward along the basin margin at Thomas and Whites Creeks, and along the northwest side of Steamboat Hills (Bingler, 1975). Another prominent set of faults trends N. 20° to 45° E. and is concentrated in a 2-mile-wide zone located immediately northwest of the Truckee River in west Reno.

4. Areal Geology. The Truckee River follows a winding eastward course through the Truckee River valley west of Reno and into Truckee Meadows east of Reno and Sparks. The distribution of geologic materials within the project area is shown on the Areal Geologic map, Figure 1, and they are described in the NBMG Reno Folio, and in Bingler (1975). The entire project area is underlain by late Pleistocene Donner Lake and Tahoe glacial outwash deposits.

The outwash has been reworked by the Truckee River and deposited along its modern floodplain overlying Tahoe outwash. Near the western end of the project area the Donner Lake outwash consists of a veneer over bedrock and is about 30 feet or less in thickness It thickens eastward to about 330 feet or more under Reno. Similarly, the Tahoe outwash forms an extensive alluvial wedge, thickening eastward from about 300 feet in west Reno to over 1000 feet beneath Sparks. Both the Tahoe and Donner Lake deposits contain large boulders known to be at least 16 feet in diameter. East of Reno International Airport the Tahoe outwash is overlain by varying thicknesses of Holocene floodplain and lacustrine or swamp deposits. Adjacent areas are covered by alluvial fan and pediment deposits. The floodplain materials consist primarily of silt, clayey silt, and silty sand containing scattered thin lenses of peat, 1 to 2 feet thick, and clay-rich interbeds. The materials vary in thickness from a feather-edge against Tahoe outwash to as much as 27 feet in northeastern Truckee Meadows.

The Soil and the Physical Properties Map in the NBMG Reno Folio indicate there are areas of poorly drained soils scattered along the Truckee River through Reno and Truckee Meadows. The mainstream and glacial outwash deposits generally have medium to high permeability, low compressibility, low shrink-swell potential, excellent drainage, good bearing capacity, low plasticity, and low relief. The floodplain and lake deposits have discontinuous layering, impervious to low permeability, moderate to high compressibility, low to medium shrink-swell potential, impervious to fair drainage, fair to poor bearing capacity, low to high plasticity, susceptibility to liquefaction, and low relief.

The Hydrologic Map in the NBMG Reno Folio shows the depth to the water table adjacent to the Truckee River through Reno and Sparks to be about 20 feet, although much of the area is shown as a fairly continuous, probable ground-water discharge area, the intensity of which varies seasonally. Water depths are expected, according to drilling data from foundation reports on construction throughout Reno, to vary considerably from about 4.5 to 20 feet for most of the western project area and from about 6 to 12 feet in Truckee Meadows.

The distribution and relative age of fault traces in the Reno area are shown on the Earthquake Hazards Map of the NBMG Reno Folio. A prominent set of northeast-trending faults of early to middle Quaternary age occur in northwest Reno and those shown in central Reno are post-Illinoian. One northeast-trending fault of post-Wisconsin age crosses the Truckee River north of the Reno International Airport. About 1-mile northeast of that fault, there is a short, more northerly trending fault that may cut Holocene deposits believed to be laterally equivalent to other deposits dated at 2130 years old. The east margin of Truckee Meadows is bounded by a fault of late Pleistocene to possibly Holocene age. Also, an obscured fault, with indications of fairly recent activity, may lie due north of the sewage facility through the center of Sections 11 and 2 (John Shilling, NBMG, oral communication). Areas underlain by glacial outwash and mainstream deposits of the Truckee River are believed to be potentially unstable and subject to pronounced slumps and ground disturbances along steep cuts or embankments during a major seismic event. Areas underlain by Quaternary floodplain and lake deposits are subject to liquefaction, severe ground motion, and surface dislocation, especially in areas of ground-water discharge or where the soils are saturated.

5. Regional Seismicity and Faulting. Extreme western Nevada is in Seismic Zone 3, which has a moderate-to-high earthquake hazard (Figure 2). Seismicity of the Reno area is average for the Western Basin and Range province, although, about 40 miles east of Reno is the 118° Meridian Zone that is considered to be historically the most active zone in the United States. It is in Seismic Zone 4. In historic time, the most severe earthquakes in the area include those of magnitudes 6.0 and 6.4 just south of Reno in 1914, magnitude 6 earthquakes near Virginia City in 1869 and near Verdi in 1948, and a magnitude 5.7 earthquake north of Truckee in 1966. Historic earthquakes of unknown magnitude occurred on the Fort Sage fault near Herlong, California in 1850 and on the Mohawk Valley Fault northwest of Sierraville, California in 1875. Major historic earthquakes in western Nevada in the 118° Meridian Zone are tabulated below:

Date	Location	Magnitude	Distance from Reno (Miles
1845	Stillwater Area	Unknown but strong	50
1872	Owens Valley	8.3	170
1915	Pleasant Valley	7.8	110
1932	Cedar Mountains	7.3	105
1954	Fallon-Stillwater Area	6.6	70
1954	Fallon-Stillwater Area	6.8	70
1954	Fairview Peak-Dixie Valley	7.3	90
1954	Fairview Peak-Dixie Valley	6.9	90

From 1940 to 1970, approximately 70 earthquakes with magnitude 4 or greater occurred within 100 km (62 miles) of Reno. The Earthquake Epicenter Map (Figure 3) shows the magnitudes and relative density of epicenter locations around Reno and eastward. The two 1914 earthquakes noted above are not plotted on the epicenter map because of uncertain location data (Trexler, oral communication). The first had an intensity of VII (Modified Mercalli Scale) in the Truckee Meadows area. It cracked buildings and had two distinct

From TM 5-809-10/ NAVFAC P-355/AFM 88-3; Chapter 13; April 1973

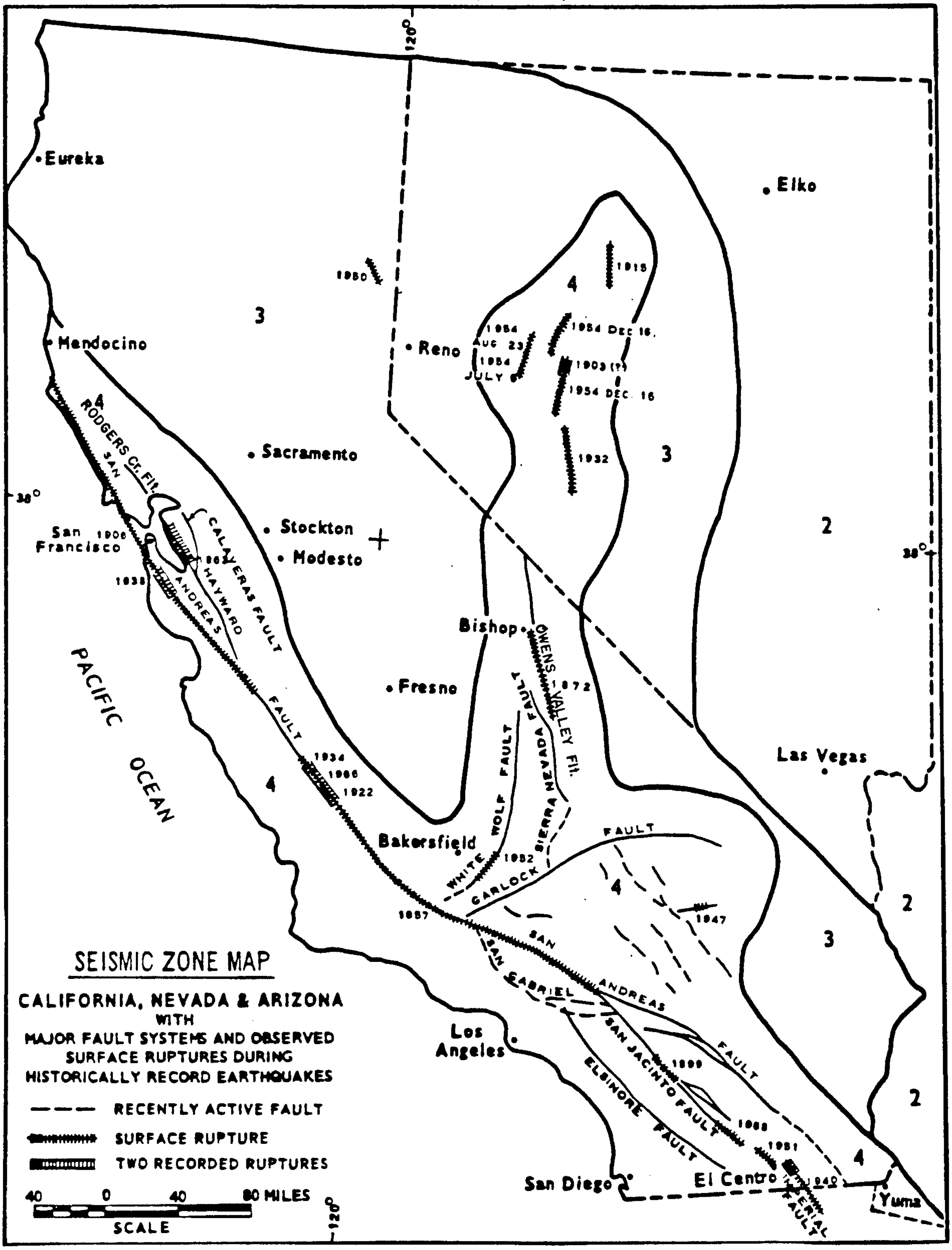
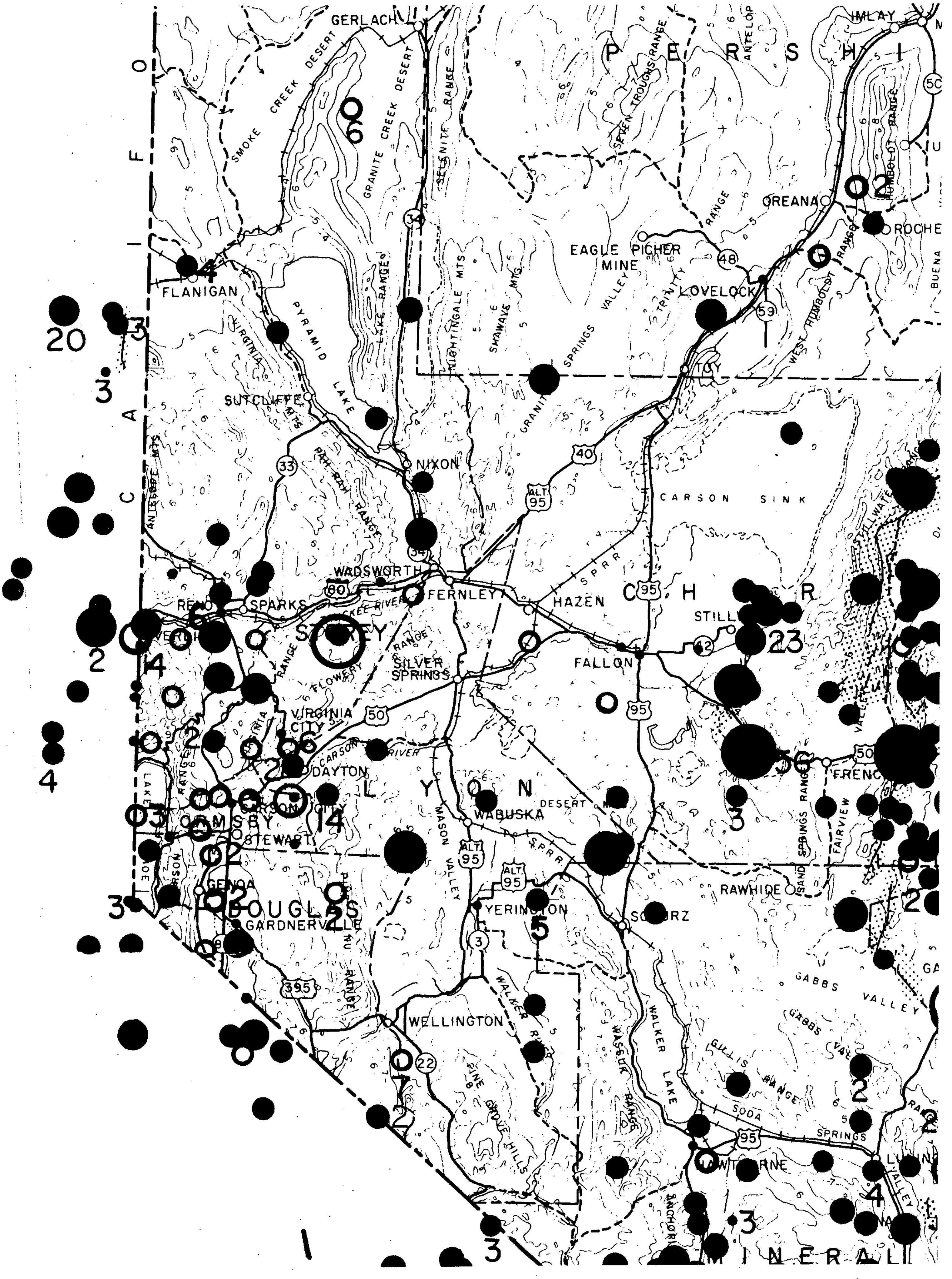
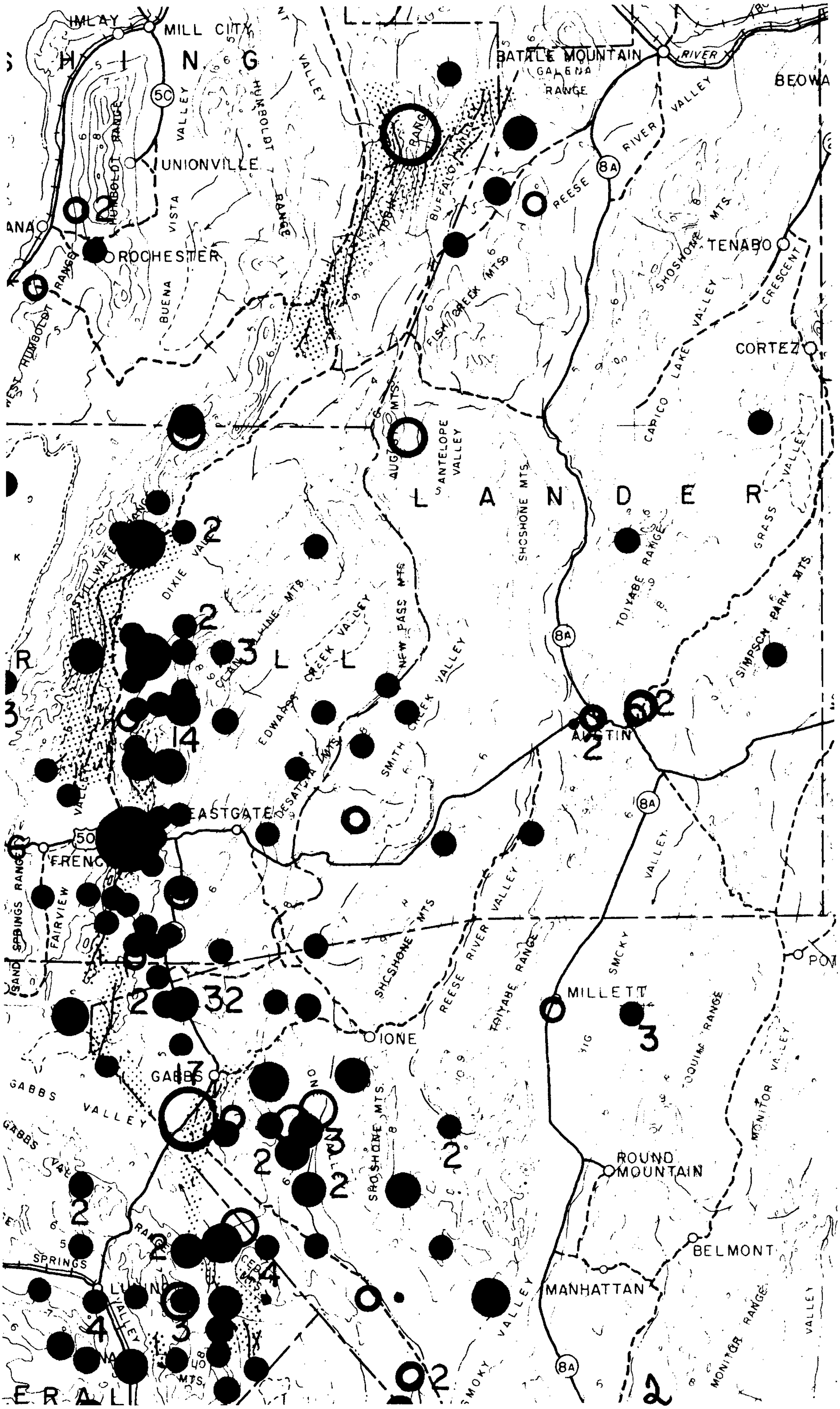


Figure 2



GERLACH
IMLAY
SMOKE CREEK DESERT
GRANITE CREEK DESERT
SELENITE RANGE
SEVEN TROUGHS RANGE
ANTELOPE
HUMBOLDT RANGE
OREANA
EAGLE PICHER MINE
LOVELOCK
FLANIGAN
PYRAMID LAKE
LAKE RANGE
NIGHTINGALE MTS
SHAWAVE MTS
SPRINGS VALLEY
TRINITY RANGE
WEST HUMBOLDT RANGE
TOY
SUTCLIFFE
VIRGINIA MTS
NIXON
RAH RAH RANGE
CARSON SINK
WADSWORTH
FERNLEY
HAZEN
RENO
SPARKS
TRUCKEE RIVER
FLOWERY RANGE
SILVER SPRINGS
FALLON
VIRGINIA CITY
DAYTON
CARSON RIVER
CARSON CITY
ORMSBY
STEWART
L Y O N
WABUSKA
DESERT MTS
MASON VALLEY
SAND SPRINGS RANGE
FAIRVIEW
GENOA
DOUGLAS
GARDNERVILLE
YERINGTON
SCHURZ
RAWHIDE
GABBS VALLEY
WELLINGTON
WALKER RIVER
WASSUK RANGE
WALKER LAKE
GILLIS RANGE
SODA SPRINGS
HAWTHORNE
PINE GROVE HILLS
M I N E R A L
SPRR
20
3
2
14
4
6
23
36
5



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EARTHQUAKE EPICENTER MAP, RENO, NEVADA AREA

COMPILATION: D. B. SLEMMONS, J. I. GIMLETT, A. E. JONES, R. GREENSFELDER, J. KOENIG

MAGNITUDE SCALE

1854 - 1931		1932 - 1960
○	7.0 +	●
○	6.0-6.9	●
○	5.0-5.9	●
○	4.0-4.9	●
	Low Magnitude, felt	•

DECEMBER 1964

NOTE:
Figures adjacent to circles indicate the number of events that occurred at those locations.

Zones of historic surface faulting; faults indicated by solid lines.

Nevada Bureau of Mines
University of Nevada
Reno, Nevada

Base from NBM Map 17

Scale 1:1,000,000

3

0 10 20 30 40 50 100 Miles

0 10 20 30 40 50 100 Kilometers

Contour Interval 1000 Feet

shocks lasting from 6 to 30 seconds. The second had an intensity of VIII in Reno. It lasted 10 seconds and toppled chimneys in the area.

Two major fault systems are responsible for most of the seismic activities in western Nevada. The Sierra Nevada Frontal System is an irregular zone of major and secondary faults extending from the Garlock fault northward along the east side of the Sierra Nevada for more than 400 miles. A second major zone, that may be related to the frontal system is the 118° Meridian Zone that trends southwest from Winnemucca to at least Owens Valley. Reno lies between these two major zones. According to the Earthquake Hazards Map in the NBMG Reno Folio, faults shown on the geologic map (Figure 1), may be splay faults from the frontal fault system. Most of them are normal faults that dip to the northwest, although some dip northeast. Many of these faults have been stratigraphically age dated (Bingler, 1975). They displace Pleistocene alluvial fan deposits and pediment gravels, and a few cut Holocene deposits. Cordova (1969) has found three to five separate movements on faults just south of Reno on the Mount Rose fan complex, during Holocene time (the last 11,000 years). According to Bingler (oral communication), a zone of recent micro-seismic activity is centered about 9 miles south of the Truckee River in the vicinity of Steamboat hot springs. For lack of evidence to the contrary, the faults cutting through the area must be considered to be capable faults.

Earthquakes with magnitudes of 7.25 to 7.6 could be centered in the area immediately south of Reno (Ryall and Douglas, 1975; D. B. Slemmons, personal communication). Slemmons also believes that the northeast trending faults in the area are capable of generating 6.0 to 6.5 magnitude earthquakes.

Discussions of recurrence curves, bedrock accelerations, and return periods in the NBMG Reno Folio gives the following data for an average site in western Nevada, including the Reno area. Small accelerations (0.1g or more) have return periods of about 13 years when caused by earthquakes with magnitudes of 5 or greater; 33 years when caused by magnitude 6 or greater (more distant) earthquakes; and 140 years when caused by magnitude 7 or greater (distant) earthquakes. Accelerations of 0.3g or more are caused by earthquakes large enough (magnitude 6 or greater) to have more than 10 seconds duration and have return periods of about 200 years. Accelerations of 0.5g or more are caused by nearby great earthquakes (magnitude 7 or greater) and would be expected only about once in 2,000 years.

6. Subsurface Explorations and Studies by Others. Appendix A lists a collection of existing soil explorations in and adjacent to the Truckee River. These soil explorations have been made by various architect and engineering firms in Reno and by local government agencies. The project area is shown on maps A, B, and C. Locations of soil explorations are shown on these maps (Segments of USGS 7-1/2 minute quadrangles). The soil logs are listed by project in Appendix A.

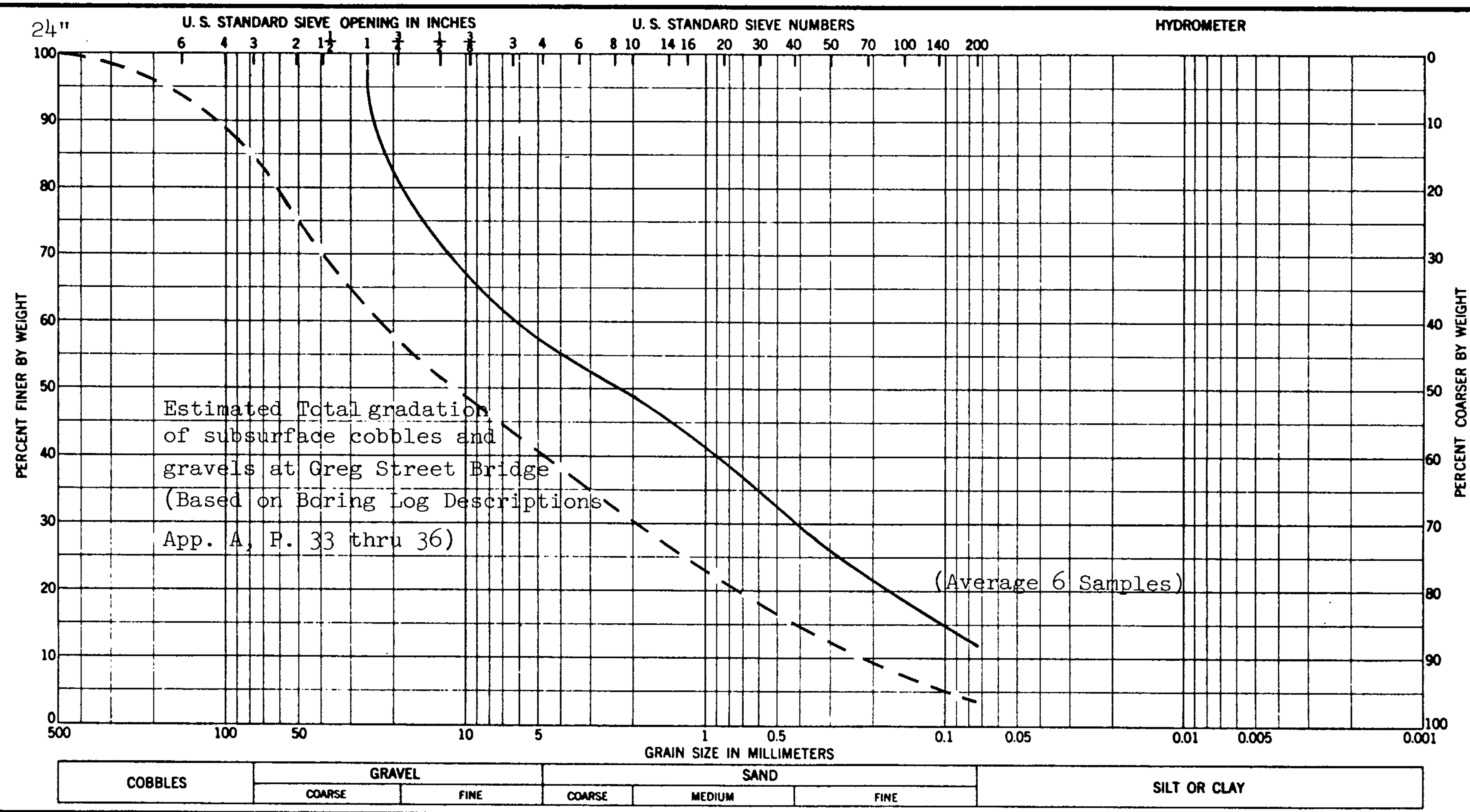
7. Summary of Foundation Information. The following paragraphs summarize information obtained from the soil exploration logs.

a. General. The majority of the soils in and adjacent to the Truckee River were derived from Donner Lake and Tahoe outwash deposits. These materials are generally composed of silty sand, sandy gravel, sand, gravel, cobbles, and boulders. Deposits of larger size material are found furthest

upstream and decrease in size downstream (towards the east). In the riverbed of the Truckee River, loose to slightly compact sand, gravel, cobbles, and boulders (about 5%), decreasing in size from west to east, comprise the upper 5 to 10 feet. Beneath the streambed deposits, dense claybound sand, gravel and cobbles are found indicating evidence of the most recent scour depths. These scour depths are shown on soil logs for the Keystone Avenue Bridge (6.0 to 6.5 feet), the Wells Avenue Bridge (5.3 to 8.0 feet), and the Rock Boulevard Bridge (10.4 to 13.0 feet from riverbank elevation).

Explorations performed adjacent to the river indicate a trend of decreasing material size from west to east. At the west end of the project, materials are generally silty sand and gravel near the surface. These contain 15 to 40 percent nonplastic to slightly plastic fines. For depths between 4 and 10 feet, material size increases to sandy gravel with 0 to 15 percent fines.

This interval contains cobbles and occasional boulders. Toward the east end of the project, immediately north of the Truckee River, soils consist of silt and sandy silt with 70 to 85 percent nonplastic to slightly plastic fines. Material size increases with depth to silty sand and gravelly sand with 5 to 25 percent nonplastic fines and occasional cobbles. Figure 4 is a plot of the average gradation of minus 1-inch materials in the vicinity of the Truckee River near Keystone and Arlington Avenues. Based on boring logs for the Greg Street Bridge (Appendix A), the total gradation of the local subsurface deposits is approximately as shown on the dashed curve on Figure 4. Figure 5 is a plot of the average gradation of the floodplain and lake deposit surface silt. Also, at the east end of the project, immediately south



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
	1' - 13'	Silty Gravelly Sand (SM)	9.2	-	-	-

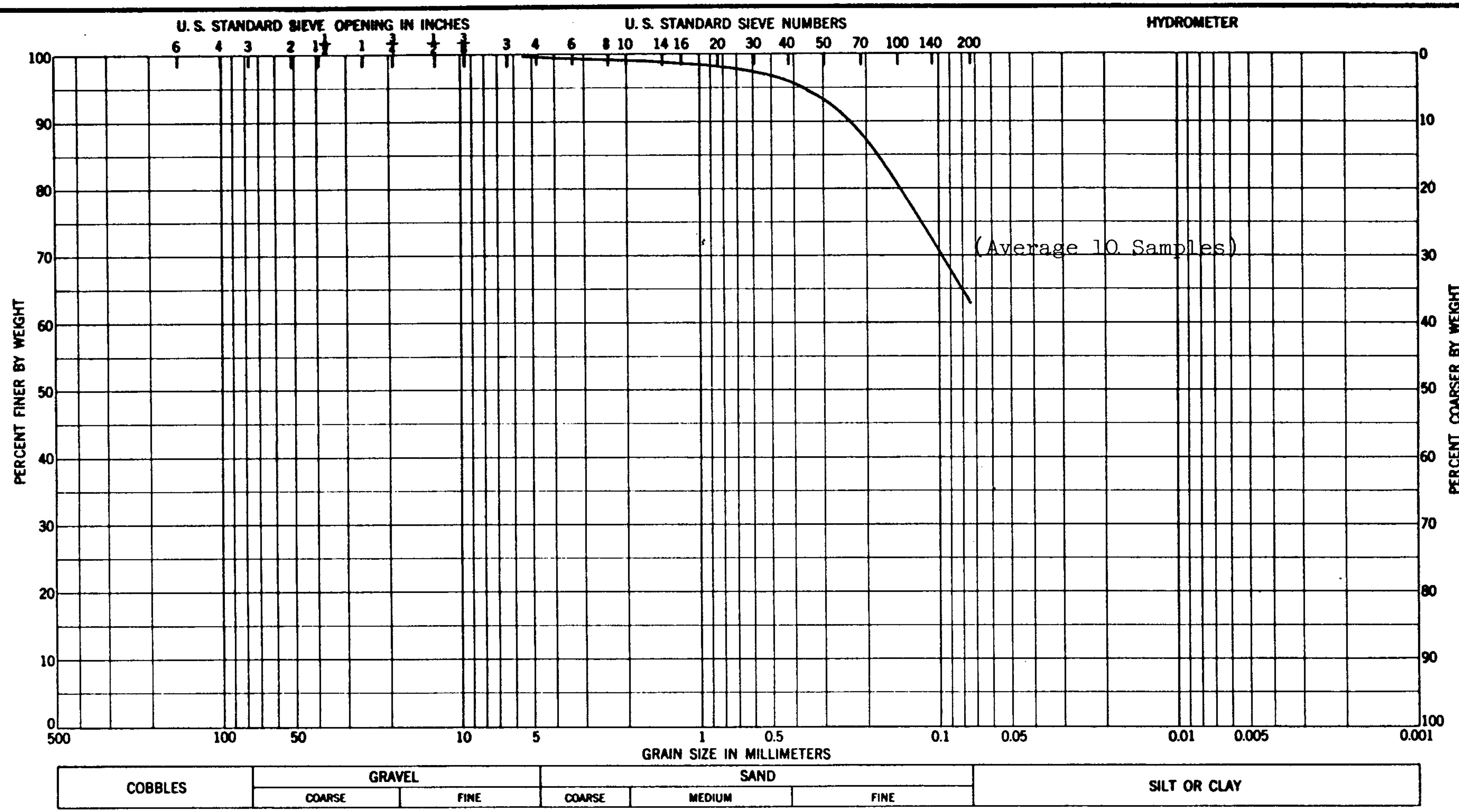
Project TRUCKEE MEADOWS INVESTIGATION
SOILS AND GEOLOGY OFFICE STUDY

Area Average gradation for borings 4, 5, 21 and 22 between Booth Street and Arlington Ave. (minus 1" fraction)

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 4



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
	1' - 9'	Silt (ML)		39	31	8

Project TRUCKEE MEADOWS INVESTIGATION
SOILS AND GEOLOGY OFFICE STUDY

Area Average gradation for borings 36, 39,42,46,47,49,54 & 55 btw. Linda Way & 1 mile west of Sewage Disposal Plant

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 5

of the Truckee River, eight auger holes were drilled. This area has from 4 to 17 feet of silt and some silty sand. Beneath the silt, medium dense to dense, poorly graded sand (SP) is encountered. At a depth of 25 feet, the sand is underlain by poorly graded gravel (GP). Water table depths in May 1977 varied from 4 to 12 feet. The U.S. Soil Conservation Service reports that seasonal high water table depths vary from 0 to 18 inches below the ground surface in meadows adjacent to the river.

b. Engineering Properties. The availability of secondary laboratory testing is minimal. Some test results were obtained on the silt from the north side of the Truckee River, east of Boynton Lane. Through conversations with one architect and engineering firm in the area, it was reported that surficial silt between 1 and 5 feet in depth, have direct shear strengths of $\phi = 22°$ to $28°$ and a cohesion of 0 to 50 pounds per square foot (psf). Test results on the silt indicated compression indices ranging from 0.08 to 0.14 and dry unit weights ranging from 77 to 90 pounds per cubic foot (pcf). Relative Density in a silty sand (soil exploration location 5 and vicinity) ranged from 80 to 89 percent. Standard penetration resistance in the silt indicate low N values of 5 to 10, while the riverbank and adjacent sand and gravel matrix materials have N values 10 to 100 (avg. 70). The NBMG Reno Folio indicates permeability of the sand and gravel in and adjacent to the Truckee River is medium to high, while that of the silt (primarily east of Boynton Lane) is low.

8. Scour. Evidence of scour was found during a field reconnaissance at several structures in the Truckee River. Scour of at least 2 feet depth was noted at bridge pier footings in at least four locations. Evidence of scour

undercutting floodwalls was also discovered through the downtown area. The most critical undercutting was found beneath the floodwalls on the south side of the Truckee River in the downtown area. A rubble wall on the south side of the Truckee River, just upstream of Virginia Street also shows signs of being undercut. The toe of the wall is breaking up. Since progressive failure of this wall is apparent, complete replacement is recommended. At other locations where undercutting was evidenced, it appeared that some wall tilting was occurring. The damaged floodwalls should be replaced with new floodwalls that have footings founded below recent scour depths. Earth Sciences, an A-E firm in Reno, reported that recent scour depth in the Truckee River is generally from 4 to 6 feet. This information is supported by the soil logs on the Keystone Avenue Bridge and Wells Avenue Bridge which indicate recent scour depths of 5 to 8 feet in the riverbed. Figure 6 shows the estimated streambed and scour elevations based on limited available data.

9. Typical Riverbank Slopes. The condition of the slopes along the Truckee River vary extensively throughout the project study area. On the upstream reaches outside of the downtown area, slopes vary from 1V on 1H to 1V on 2H. Locally, the slopes are covered with brush and trees. Boulders up to 3 feet in diameter are common on the slopes and at the toe of slopes. Along the downstream reaches east of downtown, the slopes are generally in the same condition. Slopes in the downstream reaches appear to have more cobbles and smaller boulders than the upstream reaches. The riverbanks east of the Reno International Airport consist mostly of gravelly sand and the streambed deposits consist of an estimated 5 to 10 feet of fine sandy gravel. Slopes investigated during the field reconnaissance appeared to be stable with no indication of recent failures.

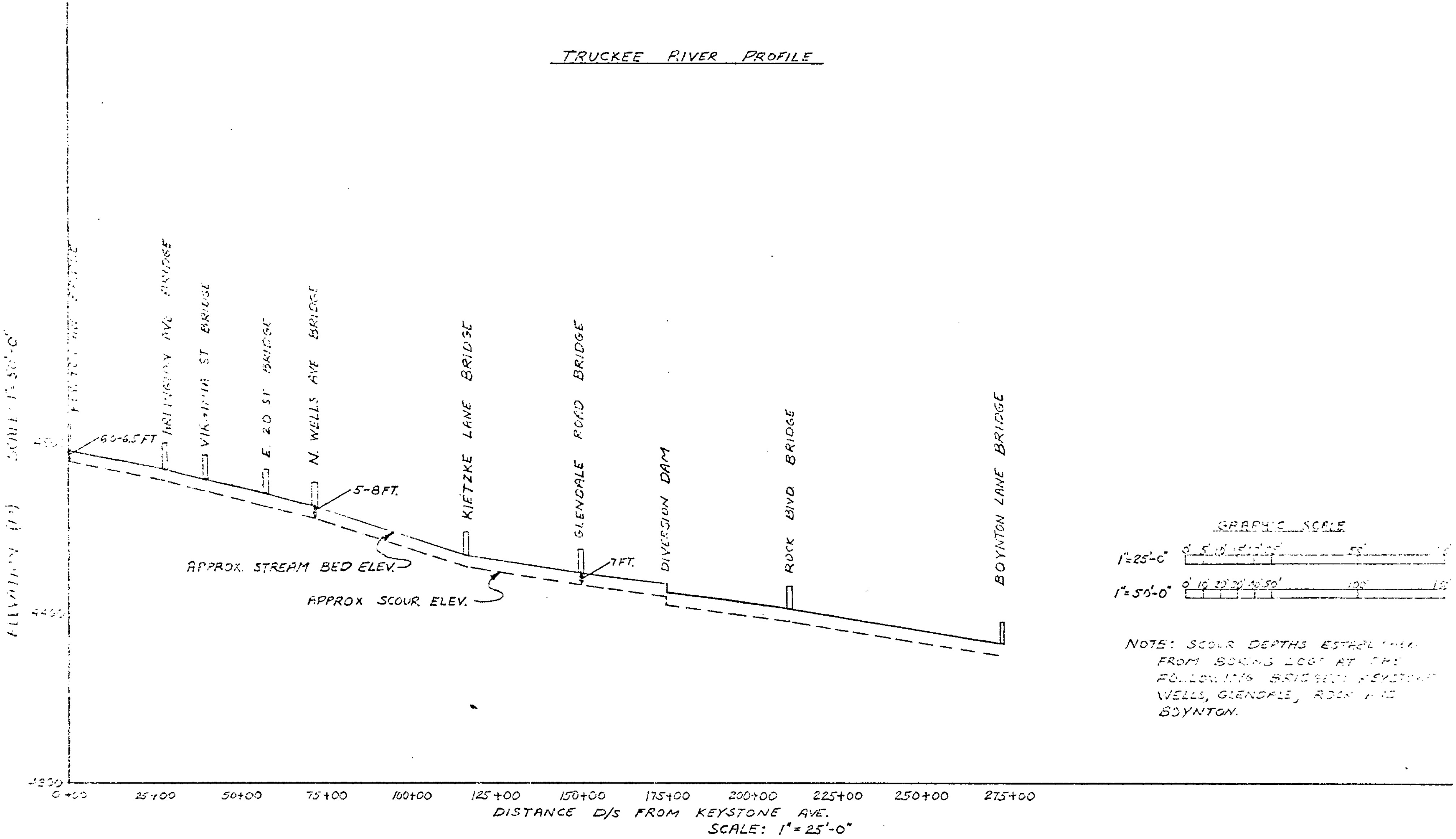

TRUCKEE RIVER PROFILE
VIRGINIA ST BRIDGE
E. 2D ST BRIDGE
N. WELLS AVE BRIDGE
KIETZKE LANE BRIDGE
GLENDALE ROAD BRIDGE
DIVERSION DAM
ROCK BLVD BRIDGE
BOYNTON LANE BRIDGE
6.0-6.5 FT
5-8FT.
7FT.
APPROX. STREAM BED ELEV.
APPROX SCOUR ELEV.
0+00
25+00
50+00
75+00
100+00
125+00
150+00
175+00
200+00
225+00
250+00
275+00
DISTANCE D/S FROM KEYSTONE AVE.
SCALE: 1"=25'-0"
GRAPHIC SCALE
1"=25'-0"
1"=50'-0"

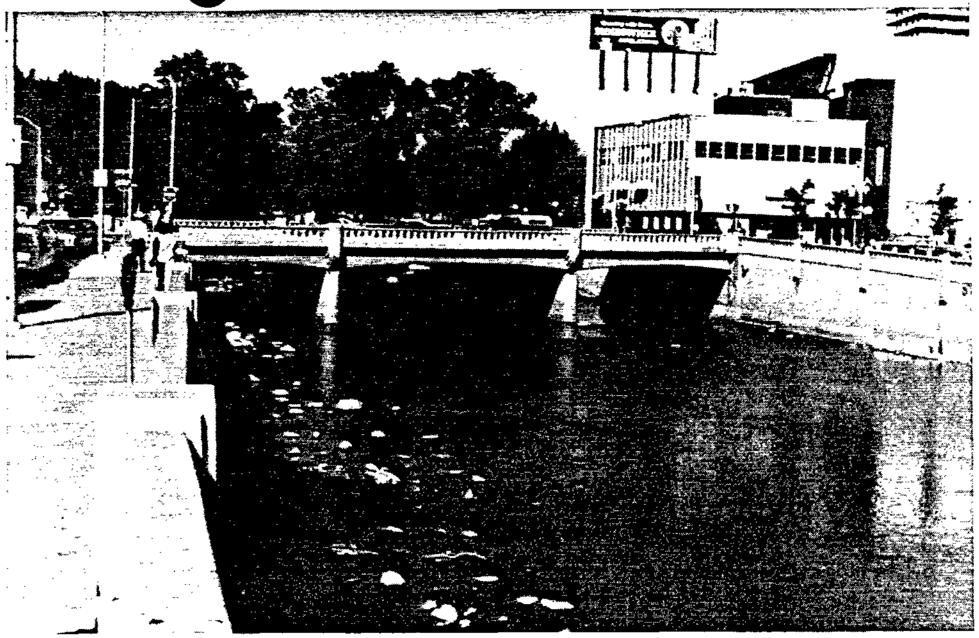
Figure 6

From Wingfield Riverside Park to Lake Street, existing banks of the Truckee River are supported by concrete floodwalls.

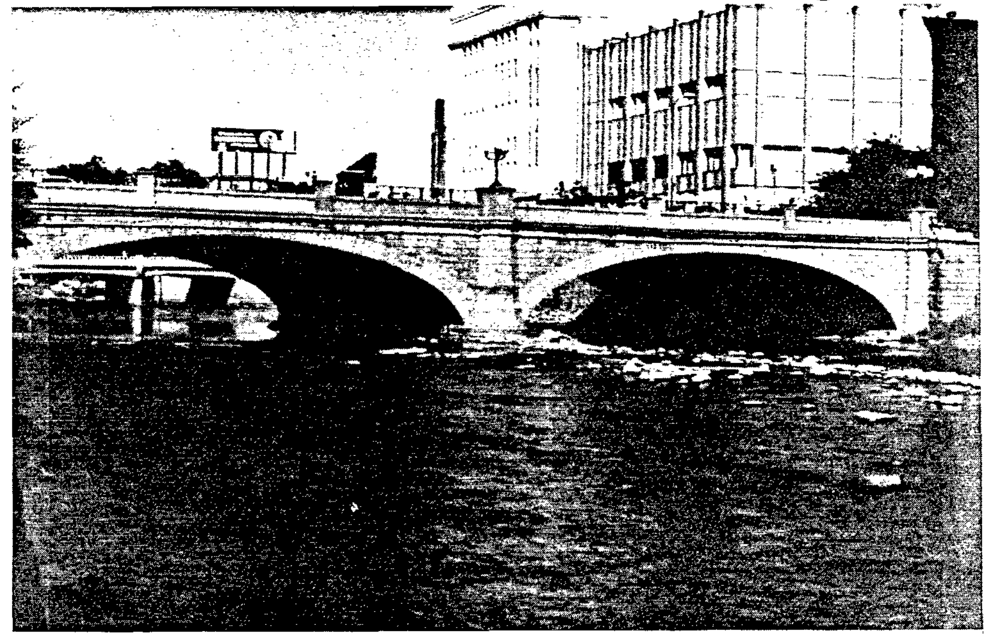
10. Seepage. Seepage or water from some other source was observed discharging into the river below the damaged rubble wall at Virginia Street. This flow was estimated to be from 50 to 60 gpm. No other signs of seepage along the slopes of the Truckee River were noted during the field reconnaissance. Numerous drain pipes and storm drains empty or discharge into the river. The majority of the these drains are found in the downtown area.

11. Existing Structures. The Truckee River project area from Twin Lakes Road to a point 2 miles east of the town of Vista has several structures that will require structural engineering consideration. Existing structures include seventeen bridge locations, two foot bridges, five debris or diversion dams, one above ground pipe crossing, one five foot square water intake structure, floodwalls through downtown Reno, and an undetermined number of pipe crossing under the Truckee River.

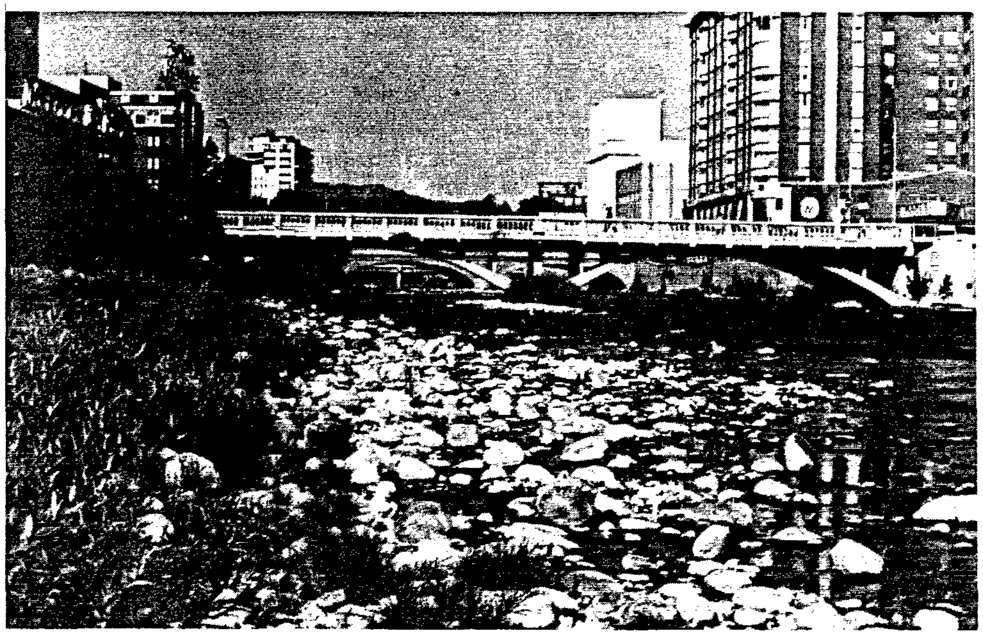
At least four of the 17 bridges greatly reduce the river capacity and will need to be replaced or raised. These four bridges, located in downtown Reno, include the Sierra Street Bridge, Virginia Street Bridge, Center Street Bridge, and Lake Street Bridge. The Virginia Street Bridge was entered into the National Register of Historic Places in December 1980. Photos of these bridges are shown on Figure 7. Several utility pipes and conduits are attached to, or suspended from, each of these bridges and will require relocation if the bridges are replaced. The two foot bridges are located at Wingfield Riverside Park, just downstream of Arlington Avenue.



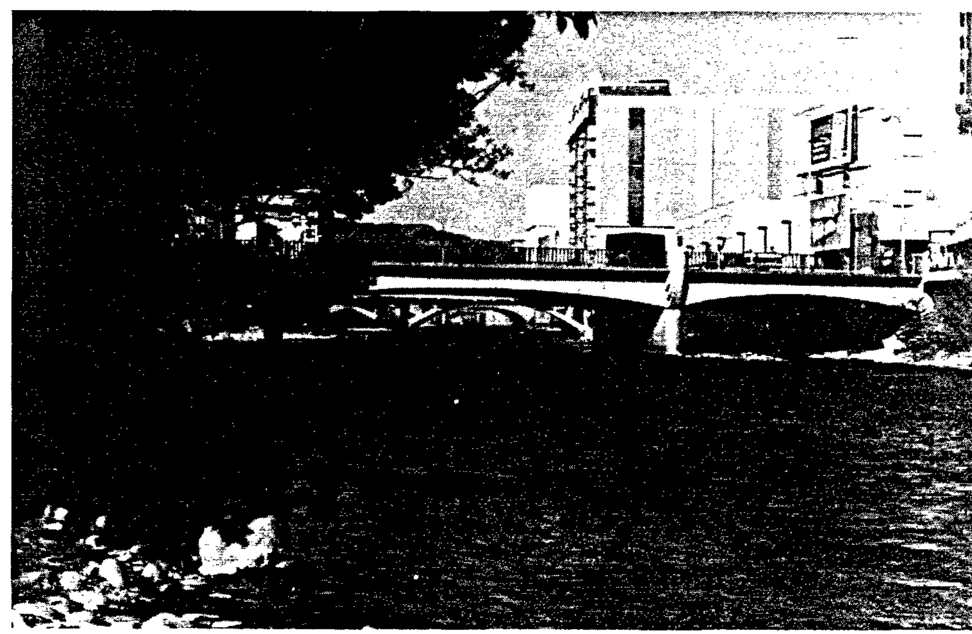
Sierra Street Bridge



Virginia Street Bridge



Center Street Bridge



Lake Avenue Bridge

Figure 7

The locations of the debris and diversion dams are as follows: one just upstream of Idlewild Park; two at Wingfield Park; and one upstream and one downstream of the Greg Street Bridge. The dams are concrete-weir structures extending across the Truckee River.

An 18-inch sewer line, owned by the city of Reno, crosses the Truckee River at Locust Avenue east of Wells Avenue. The invert elevation is nearly equal to the riverbank elevation. A sewerline project is presently underway in Reno. The project parallels and crosses the river near Bell Street with a 33-inch-diameter reinforced concrete pipe. The invert of the pipe is 6 feet below streambed. A complete list of the water supply lines or sewer lines crossing beneath the Truckee River has not been obtained.

An irrigation water intake structure is located approximately 50 feet upstream from the Sierra Street Bridge on the south side of the Truckee River. The 5-foot-square structure serves as an intake for Cochran Ditch. Cochran Ditch conveys water to Virginia Lake, approximately 1-3/4 miles south of the intake structure. Any channel work between the Arlington Avenue Bridge and the Sierra Street Bridge may require modification of the intake structure.

12. Source of Construction Materials.

a. Concrete. Concrete materials are readily available in the Reno Sparks area. A large sand and gravel company is located between Reno and Sparks and several ready-mix concrete companies are located in Reno.

b. Soils. Based on the NBMG Soils map, a potential source of suitable material is located in West Reno. Stony clay mantles the slopes in the area shown on Map A. This potential borrow will require a 1 to 2-mile haul distance. Materials adjacent to the Truckee River are not available since these areas are commercially developed. Streambed cobbles and boulders are rounded and will not provide stable slope protection, unless placed in gabions or on flat channel slopes. A quarry would have to be developed to provide angular riprap. The downstream end of the project, east of the Reno International Airport, comprises the Tahoe flood plain. The materials in this area consist primarily of silt suitable for levee construction.

13. Flow Restrictions. Several flow restrictions were observed along the Truckee River. These include large boulders in the riverbed, especially upstream bridges in the downtown area (see paragraph 11) and brush and trees growing on the slopes throughout the project area also restrict flow.

14. Summary and Conclusions.

a. Streambed. Streambed deposits are very coarse grained upstream from Greg Street Bridge and predominantly consist of gravel, cobbles, and boulders with some sand. The cobble and boulder fraction gets progressively coarser upstream with some boulders over 4 feet in diameter. Downstream from Greg Street, material sizes decrease and boulders are scattered. Gradation data is limited and samples included in Appendix A reflect grading of minus 3-inch sizes only. Collectively, the surface materials are loose to the reported scour depths of about 5 feet, along upstream reaches of the river, and to about 7 feet along the downstream reaches.

b. <u>Riverbank and Adjacent Deposits</u>. The riverbank and adjacent deposits are much finer grained than the streambed deposits. The bank deposits consist of sandy gravel, cobbles, and scattered boulders upstream from Greg Street. Downstream, the bank material gets finer and includes gravelly sand, silty sandy gravel, and silt. Surficial silty sand typically blankets the areas adjacent to the river upstream from Greg Street. The sand gets progressively finer grained downstream and grades into meadow silt in the vicinity of the Reno International Airport. The surficial sand and gravel are typically loose to depths of 5 to 10 feet. The meadow silt is soft, weak, highly compressible, and has a high liquefaction potential.

c. <u>Subsurface Gravel</u>. Subsurface gravel deposits are typically dense with Standard Penetration N values ranging from 50 to 100 and averaging 70. These dense gravels are encountered below the scour line under the riverbed and at depths of 5 to 15 feet along the riverbanks and adjacent areas. Downstream from the Reno International Airport, these gravel deposits are covered with 15 to 27 feet of silt.

d. <u>Construction</u>. Levees, channel modifications, and bank slope protection can be feasibly constructed along the Truckee River in the Reno Area. Dense gravel deposits will provide an excellent foundation for bridges and floodwalls. Borrow will have to be imported for levee construction along the upstream reaches. Explorations will be required to confirm borrow properties and quantities. Levees constructed in the meadows east of the airport will have to allow for settlement and have relatively flat outer slopes. The silt deposits are erodable and the waterside slopes will require riprap. Local borrow can be used to construct these levees.

15. Selected References. The following published reports and maps contain information pertaining to the geology, soils, and seismicity of the project area.

a. Appendix A, collection of soil logs from public agencies and private architect engineering firms in Reno.

b. Bingler, E. C., 1975, Guidebook to the Quaternary Geology Along the Western Flank of the Truckee Meadows, Washoe County, Nevada, Nevada Bureau of Mines and Geology Report 22.

c. Nevada Bureau of Mines and Geology, 1976, Environmental Folio Series, Reno Quadrangle, Reno, Nevada, 52 p., 10 pl.

d. Oral communication with geologists of the Nevada Bureau of Mines and Geology, namely D. B. Slemmons, J. Shilling and D. Trexler.

e. Oral communication with Larry J. Johnson of SEA Engineers/Planners, Sparks, Nevada.

f. Slemmons, D. B., et al, 1965, Earthquake Epicenter Map of Nevada, Nevada Bureau of Mines and Geology Map 29: Mackay School of Mines, University of Nevada, Reno.

g. U.S. Army Corps of Engineers aerial photographs of Truckee Meadows, Nevada and Truckee River taken 22 and 23 May 1981 by Harl Pugh & Associates of South San Francisco, California.

Section E

Watershed Sedimentation Investigation for the Truckee River Basin, Verdi to Vista

US Army Corps
of Engineers

The Hydrologic
Engineering Center

Watershed Sedimentation Investigation for the Truckee River Basin, Verdi to Vista

Prepared for

Sacramento District
US Army Corps of Engineers

Special Projects Memo No. 82-4

July 1982

WATERSHED SEDIMENTATION INVESTIGATION FOR THE TRUCKEE RIVER BASIN, VERDI TO VISTA

Robert C. MacArthur, Ph.D., P.E.

Special Projects Memo No. 82-4

Prepared for
Department of the Army
Sacramento District, Corps of Engineers

U.S. Army Corps of Engineers
Water Resources Support Center

The Hydrologic Engineering Center
Davis, California

July 1982

PREFACE

This report was prepared to review the factors that influence sediment transport along the Truckee River through Reno and Sparks, Nevada. Information, data, and observations discussed herein are intended to be used as reconnaissance level information to supplement the Phase I Feasibility Study being prepared by the Sacramento District Corps of Engineers for the Truckee River flood protection project.

The primary objectives of this report are: (1) to summarize the observations and findings from the 9-11 February 1982 field reconnaissance of the study area; (2) to discuss sediment transport characteristics of the area as they relate to the proposed channel improvements and flood protection project; (3) to identify sources and types of sediment that may enter the Truckee River along the project reach; and (4) to discuss major effects that proposed project features may have on sediment transport characteristics within the system.

Information and data used to prepare this document were extracted from the many reports, publications and personal discussions listed in the Reference section of this report.

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SUMMARY

This report presents the data and results from an investigation to evaluate the sedimentation characteristics of the Truckee River Subbasin from Verdi to Vista, Nevada. This study was performed by the Hydrologic Engineering Center, Davis, California, for the Sacramento District, U.S. Army Corps of Engineers, Sacramento.

Information pertaining to the description of the study area, its topography, geology, climate, and land usage is presented. The Truckee River Basin was partitioned into six contributing watersheds from Lake Tahoe to Vista. Each of these watersheds was analyzed for its potential sediment contribution to the Truckee River. These results were then summed and evaluated with respect to their potential impact on the proposed channel improvement and flood protection works in the study reach.

It was determined that for average annual flow conditions, the total sediment production from Lake Tahoe to Vista would be approximately 102,700 cubic yards per year or 122,700 tons per year. The estimated sediment production for the same area during a 100-year storm event is estimated to be 1.26×10^6 cubic yards per storm or 1.51×10^6 tons per storm. The potential deposition in the project area is estimated to be 51,300 cubic yards per year during average annual conditions and approximately 630,000 cubic yards per storm event due to 100-year storm events.

Current sediment-related problems along the Truckee River are minor. This report identifies several potential project-related sediment problems that may result, however. Therefore, more detailed evaluation of potential hydraulic and sediment transport problems should be conducted during the detailed project design phase. Investigation of stable channel designs and the separate comparative analysis of sediment transport capacities for riffle and pool areas should also be performed.

INTRODUCTION

History

There is a long history of Corps of Engineers (COE) involvement in flood control and watershed protection projects in the Truckee River basin, California and Nevada. A list of previous studies of the Truckee River basin that were conducted by the Sacramento District Corps of Engineers (SPK) is presented in Table 1. Early channel improvement work on the Truckee River and tributaries, California and Nevada, for flood control purposes, was authorized by the Flood Control Act of 1954. In 1964, the Truckee Meadows Investigation was authorized by a Senate Public Works Committee resolution to determine the feasibility of providing additional flood protection for the Reno-Sparks, Nevada, metropolitan area.

Appendix A gives more information on the history of the Truckee Meadows investigation which was prepared by SPK for their July 1980 report, "Truckee Meadows Investigation, Reno-Sparks Metropolitan Area, Nevada Information Summary" (Report No. 9, Table 1). Additional reports and studies prepared for the area are listed in the References section of this report.

Authority

On 24 February 1982, the Sacramento District Corps of Engineers (SPK) authorized the Hydrologic Engineering Center (HEC) to perform a reconnaissance-level study of sediment transport within the Truckee Meadows, Nevada, project area. The investigation and subsequent report were completed for SPK through Project Order No. SPKED-T-82-02.

Description of Study Area

The Truckee River basin, shown in Chart 1, is located in eastern California and western Nevada. The basin is comprised of approximately 3,060 square miles of drainage area with most of the runoff from the Truckee River basin originating above the City of Reno, Nevada. The drainage area upstream from Reno includes approximately 1,070 square miles of rugged mountains along the eastern slopes of the Sierra Nevada, the crest of which forms the western boundary of the basin (SPK, 1980-a). Within this area, 506 square miles drain directly into Lake Tahoe. The Truckee River originates at the northwestern end of Lake Tahoe where an outlet structure regulates flow into the river. From Lake Tahoe, the river flows north and then northeasterly through the cities of Truckee, California, then Reno, Sparks, and Wadsworth, Nevada, until it empties into Pyramid Lake which is 110 miles downstream from Lake Tahoe. The river basin has no outlet to the ocean (SPK, 1980-a).

Primary tributaries of the Truckee River include Donner Creek, Martis Creek, Prosser Creek, Little Truckee River, and Steamboat Creek. Flows originating upstream of Reno are partially regulated by the Lake Tahoe release structure and by the Stampede, Boca, Prosser, and Martis Creek reservoirs.

The largest tributary to the Truckee River in the Reno-Sparks area is Steamboat Creek which originates at the outlet of Washoe Lake. Evans, Dry,

TABLE 1

Previous Hydrologic Studies conducted by
the Sacramento District Corps of Engineers (SPK)
for the Truckee River Basin.

1. SPK, (July 1957), "Office Report, Truckee River Basin, California and Nevada, Standard Project Flood, Truckee River at Reno, Nevada," U.S. Army District, Sacramento, California.

2. SPK, (March 1960), "Interim Survey Report for Flood Control, Reno Area, Truckee River and Tributaries, California and Nevada, Appendix A, Hydrology," U.S. Army Engineer District, Sacramento, California.

3. SPK, (July 1964), "Operation and Nevada," U.S. Army Engineer District, Sacramento, California.

4. SPK, (October 1970), "Flood Plain Information, Truckee River, Reno-Sparks-Truckee Meadows," U.S. Army Engineer District, Sacramento, California.

5. SPK, (December 1971), "Master Report on Reservoir Regulation for Flood Control, Truckee River Reservoirs, Nevada and California," U.S. Army Engineer District, Sacramento, California.

6. SPK, (June 1972), "Flood Plain Information, Steamboat Creek and Tributaries, Steamboat and Pleasant Valleys, Nevada," U.S. Army Engineer District, Sacramento, California.

7. SPK, (June 1974), "Flood Plain Information, Truckee River and Martis Creek, Truckee, California," U.S. Army Engineer District, Sacramento, California.

8. SPK, (February 1980), "Office Report, Truckee River, California and Nevada, Hydrology," U.S. Army Engineer District, Sacramento, California.

9. SPK, (July 1980), "Truckee Meadows Investigation, Reno-Sparks Metropolitan Area, Nevada, Information Summary," U.S. Army Engineer District, Sacramento, California.

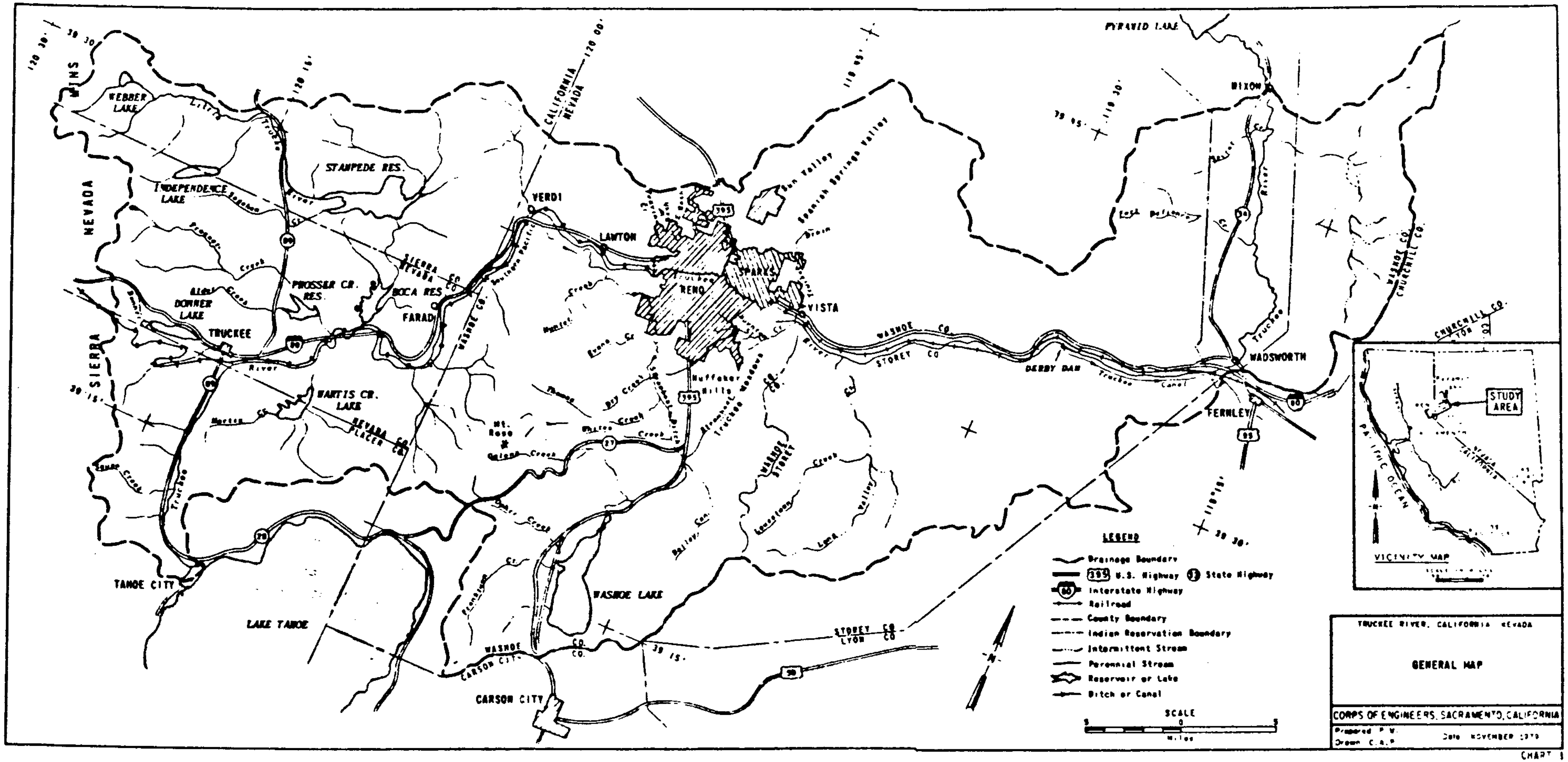


CHART 1 (SPK, 1979)

Thomas, Whites, and Galena Creeks are tributaries to Steamboat Creek and originate on the northeastern slopes of Mount Rose (SPK, 1980-a).

The major population centers in the basin are in the Reno area and around Lake Tahoe. Elsewhere, population is sparse with only a few small towns and settlements. Major urban and industrial developments occur in the Cities of Reno and Sparks, and in the Truckee Meadows area. Sparks adjoins Reno and is located to the east along the north bank of the Truckee River near the Meadows area. The approximate elevation for the Reno, Sparks and Truckee Meadows area is 4,500 feet which is 1,700 feet lower than Lake Tahoe (SPK, 1980-b).

Further descriptions of the geology, topography, soils, and vegetative cover for the Truckee River basin can be found in previous reports by the Soil Conservation Service and Corps of Engineers (SCS, 1980; SPK, 1980-a; SPK, 1980-b; SPK, 1981).

Land and Water Uses

Historically, logging, ranching and mining were the dominant land uses, while stream waters were primarily used for agriculture, livestock watering and mining. Fisheries were considered an important resource then and now.

Land uses have shifted considerably in the last twenty years. Appreciable logging is confined now to the northern sector outside the Lake Tahoe basin; sheep grazing has been severely reduced; cattle grazing is reduced but still prevalent in the nonforested areas; and surface and subsurface mining has nearly ceased. The major new impacts are associated with recreational land use and urban development.

The Truckee River supports 15 ski complexes, a whole spectrum of newly-urbanized areas, major commercial and gaming areas near Lake Tahoe and the City of Reno. In addition, there has been a tremendous increase recently in off-road traffic by backpackers, off-road vehicles (cars, motor cycles, and snowmobiles), sightseers, rock hounds, and hunters.

The principal economic activities in the Reno-Truckee Meadows area are gaming and industrial warehousing. Tourism, gaming, lumbering, farming and ranching are the primary economic activities elsewhere in the basin. According to current statistics (SPK, 1980-b), the area of Reno, Sparks, and Truckee Meadows is one of the most rapidly growing areas in the United States. The 1970 population was 121,068 in Washoe County. The projected population for 1990 is 267,291.

Problems and Needs

Water resources-related problems and needs that directly impact the Truckee River and tributaries draining into the Truckee are associated primarily with the serious flood problems that exist through Reno, Sparks and the Truckee Meadows area. Other issues of major concern that might be impacted due to the construction of a flood control project along the Truckee River include: (1) fish and wildlife interests (including the threatened Lahontan cutthroat trout and endangered cui-ui fisheries), (2) recreational interests (access and availability), (3) river water quality, (4) rapid urban development in flood prone areas, (5) aesthetic considerations with respect to

existing conditions and structures and (6) downstream impacts on river flow and sediment transport.

Excellent summaries by SPK (1980-a and b) of the flooding problems and flood control works that have been developed along the Truckee River are included for the reader's information in Appendix B. A Soil Conservation Service report entitled "Stormwater Hydrology and Conservation Treatments in Southwest Reno," (SCS, 1980) also presents a good summary of flood problems associated with the Truckee River basin. Historical peak flows recorded at the Reno gage and the estimated damage costs associated with those floods are tabulated in Appendix B.

The potential for flood damages along the Truckee River has continued to increase in recent years as a result of uncontrolled flood plain development. Flood plain zoning and controlled construction methods could be implemented to help minimize future damages. The Corps of Engineers has been asked to conduct additional studies to evaluate and select a viable channel modification plan from Lawton to Vista, Nevada, to help alleviate flooding problems. Unfortunately, most studies have been based on "existing" conditions, not knowing the extent of future development along the river. This is because it is difficult to predict future amounts of development in an area already considered to be a "poor choice" for further urban or industrial expansion due to eminent flooding dangers.

Another important problem and the major topic of this investigation is related to sediment production and transport through the Reno, Sparks and Truckee Meadows area. Quite often sediment-related problems occur during and after flood flows. Rain storms and melting snow cause water-induced soil erosion. Erosion of fragile upland forest and range land accounts for about three-fourths of the gross erosion in the Truckee River basin (SCS, 1980). Sheet and rill erosion are responsible for approximately 70 percent of the total water-induced erosion, with channel bed and bank erosion contributing the remaining 30 percent. Severe erosion is estimated by the SCS (1980) to occur on 16,000 acres with moderate erosion on 2,000 acres. Actual amounts of eroded material and the estimated sediment yields will be discussed in a following section.

In addition to water-induced erosion, aeolian erosion (wind erosion) occurs over most of the range lands and flat portions of the Truckee River basin.

Man-induced erosion and sediment production occurs at various locations throughout the basin due to poorly managed agricultural and range management practices, and due to urban and recreational developments.

SUMMARY OF THE FIELD RECONNAISSANCE STUDY CONDUCTED

9-11 February 1982

Purpose of Field Investigation

The purpose of the field investigation was to conduct a reconnaissance study of the areas along the Truckee River that would be effected by proposed flood protection works. The two major goals of the field study were (1) to qualitatively evaluate the feasiblity of certain aspects of the proposed channelization and flood protection plan, and (2) to appraise current and future potential sediment related problems along the Truckee River with respect to the proposed channel improvements and flood protection project.

Spot visual inspections of the Truckee River were made from the City of Truckee down to Vista. Additional field inspections of the Truckee Meadows, University Farms overflow area, Huffaker Hills, and tributary drainages into the Truckee River were made.

Observations

General - In general, the Truckee River is a pool and riffle type perennial stream from Verdi to Vista with several man-made bridge crossings and diversion structures along the way. The channel bed is armored with materials ranging in size from pebbles and cobbles up to boulders several feet in diameter. The prevalence of large-sized bed materials such as boulders decreases from Verdi to Vista. This tendency for decreasing bed material sizes continues past Vista all the way to Pyramid Lake where the dominant grain sizes on the bed are sands and silts (Borland, 1977-a).

Flood walls and various methods of bank protection have been installed over the years through the City of Reno. Although apparently adequate for bank protection purposes, the existing revetment and flood protection structures may not be sufficiently high or the channels sufficiently wide, to be able to pass the 100-year peak discharge of 18,500 cfs.

Photographs presented in Appendix C were taken along the Truckee River through Reno, Sparks, and Truckee Meadows. Several of the photos show localized areas where sediment accumulation has occurred and a few areas where debris and overgrowth have reduced the effective channel capacity. Examination of past biannual reports from the Carson-Truckee Water Conservancy District and the Nevada State Engineers' Office to the Construction-Operations Division in SPK, indicates that these accumulations typically occur along the Truckee River and require periodic removal and maintenance (SPKCO-O, 1959-1982). Contrary to some reports (Leeds, Hill and Jewett, Inc., 1982), the exposed flood wall footings through downtown Reno are not a result of continuing channel degradation. According to the Superintendent of the Carson-Truckee Water Conservancy District (Hunter, 1982), the flood wall footings were exposed years ago when the channel bottom was excavated to increase its flood capacity. He said that he has observed a gradual aggradation of materials along the Truckee River in the cities of Reno and Sparks, not a degradation. Therefore, the exposed footings (see photos, Appendix C) are generally a result of past channel work.

In-Channel Diversions - Channel widths through Reno and Sparks vary from 125 to 200 feet, with an average channel bed slope of about 5 feet per mile. Major developments in the Truckee River channel from Verdi to Vista are itemized in Figure 1 and include the following structures: (1) Wingfield Park Island (RM 52.3+); (2) three concrete grade control/diversion structures located at Ivan Sack Park (RM 54.5+), Idlewild Park (RM 53.5+), and just upstream from Arlington Avenue (RM 52.4+); (3) five rock and boulder grade control/diversion structures located at Idlewild Park (RM 53.5+), Cochran Ditch (RM 52.3+), Rock Park near Rock Boulevard, the Pioneer-Session diversion dam, and the Sierra Pacific diversion near Glendale Avenue bridge. In addition to instream diversions, the channel banks between river miles 52.5 and 52.0 are concrete flood walls that were constructed in the 1930's.

There are approximately twenty automobile bridges and at least two foot bridges that cross the river along the study area. Pertinent data for most of these bridges can be found in Tables 2-2 and 2-3 in the recent report prepared by Leeds, Hill & Jewett, Inc. (1982). Leeds, Hill & Jewett have also located the major utility crossings and inlets and diversions to the Truckee River.

Flood Plain Development - Considerable urban development and construction of light industry and warehousing have taken place in the Sparks-Truckee Meadows area, more than was indicated on the topographic maps or even the 1981 aerial photographs that were used during the field trip. Development south of the Truckee River in the marsh area between Huffacker Hills, Steamboat Creek, and Boynton Slough is a mixture of single-family housing and large apartment complexes. Some elevation relief between McCarran Boulevard and Steamboat Creek was observed. However, at the intersection of McCarran Boulevard and Pembroke Lane, no appreciable vertical relief could be seen across the University Farms overflow areas. In addition, there was considerable residential development along the east bank of Steamboat Creek right up to the creek line upstream of the Pembroke Lane bridge.

At the bridge crossing where Pembroke Lane crosses Steamboat Creek it is very apparent that there is little difference in elevation between the proposed overflow area and the homes on the South side of Pembroke Lane. Hand level sightings from approximately the center of the overflow area indicated that several homes along the Truckee River and along Pembroke Lane and Boynton Slough would possibly be below the proposed flood elevation. This needs to be verified with more sophisticated surveying equipment.

Several residences were identified on Kimlick Lane in the extreme western portion of quadrant 15 (refer to SPK, Geotechnical Exploration Map for quadrant locations). Sludge and wastewater lagoons were observed in the northwestern portions of quadrant 14. Steamboat Creek from the intersections of Pembroke and Kimlick Lanes downstream to the wastewater treatment plant appeared to be deeply incised with nearly vertical banks. This observation indicated a major change in soil type in the area compared to Truckee River materials which are comprised primarily of noncohesive sands and gravels. Portions of the Truckee Meadows and marsh areas used to be part of an ancient lake. Therefore, surface material and soil properties through the flat meadows and marsh overflow areas are comprised primarily of finer silts and clay materials with a high amount of organic constituents.

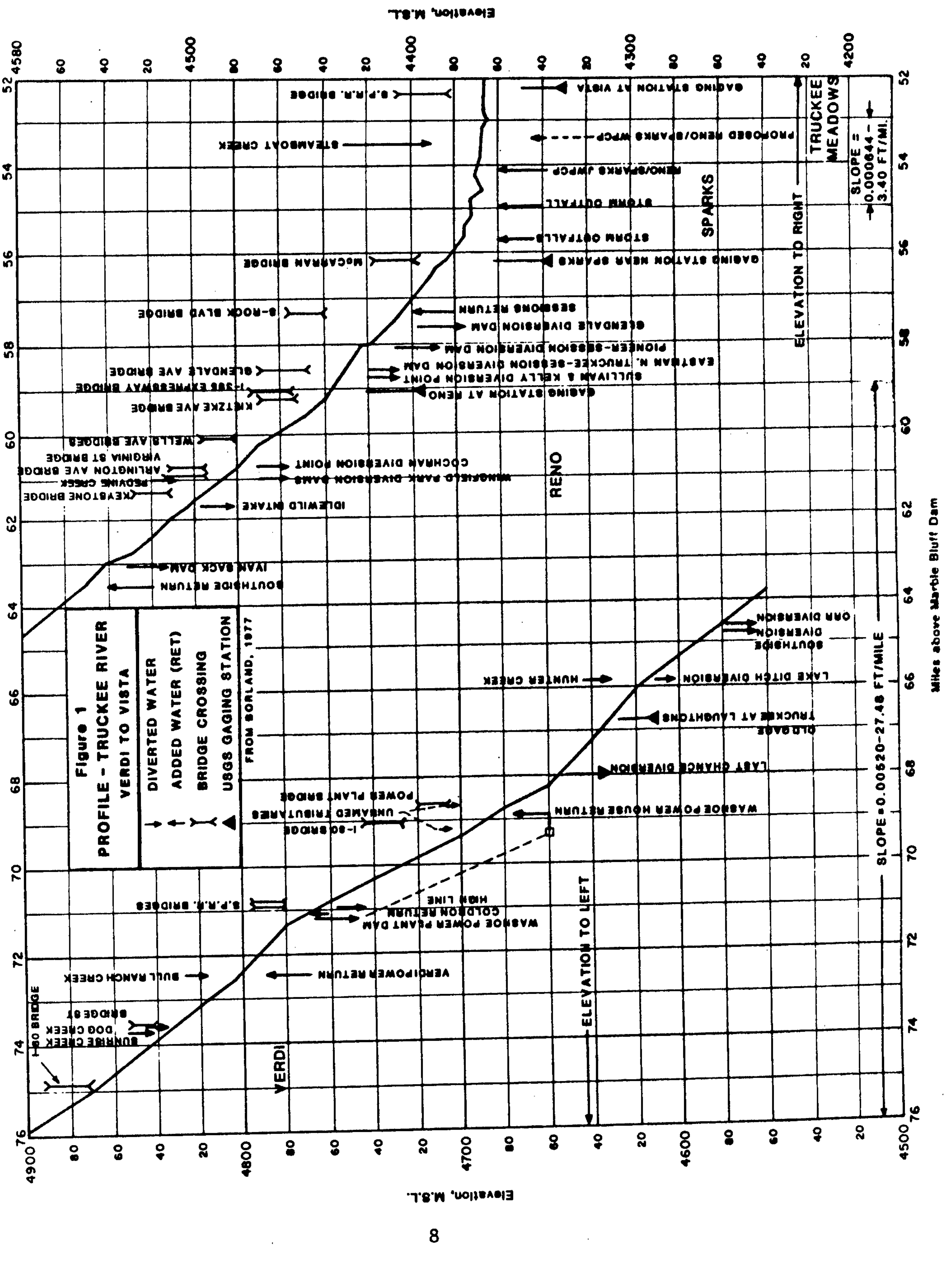


Figure 1
PROFILE - TRUCKEE RIVER
VERDI TO VISTA
DIVERTED WATER
ADDED WATER (RET)
BRIDGE CROSSING
USGS GAGING STATION
FROM BORLAND, 1977
Elevation, M.S.L.
Miles above Marble Bluff Dam
ELEVATION TO LEFT
ELEVATION TO RIGHT
SLOPE = 0.00520-27.48 FT/MILE
SLOPE = 0.000644 - 3.40 FT/MI.
TRUCKEE MEADOWS
SPARKS
RENO
VERDI
GAGING STATION AT VISTA
S.P.R.R. BRIDGE
STEAMBOAT CREEK
PROPOSED RENO/SPARKS WPCP
RENO/SPARKS JWPCP
STORM OUTFALL
STORM OUTFALLS
GAGING STATION NEAR SPARKS
McCARRAN BRIDGE
SESSIONS RETURN
GLENDALE DIVERSION DAM
S-ROCK BLVD BRIDGE
PIONEER-SESSION DIVERSION DAM
EASTMAN N. TRUCKEE-SESSION DIVERSION DAM
SULLIVAN & KELLY DIVERSION POINT
GLENDALE AVE BRIDGE
I-395 EXPRESSWAY BRIDGE
GAGING STATION AT RENO
KIETZKE AVE BRIDGE
WELLS AVE BRIDGES
VIRGINIA ST BRIDGE
ARLINGTON AVE BRIDGE
COCHRAN DIVERSION POINT
PEDVINE CREEK
WINGFIELD PARK DIVERSION DAMS
KEYSTONE BRIDGE
IDLEWILD INTAKE
IVAN SACK DAM
SOUTHSIDE RETURN
ORR DIVERSION
SOUTHSIDE DIVERSION
LAKE DITCH DIVERSION
HUNTER CREEK
TRUCKEE AT LAUGHTONS
OLD GAGE
LAST CHANCE DIVERSION
WASHOE POWER HOUSE RETURN
POWER PLANT BRIDGE
UNNAMED TRIBUTARIES
I-80 BRIDGE
S.P.R.R. BRIDGES
HIGH LINE
COLDRON RETURN
WASHOE POWER PLANT DAM
VERDI POWER RETURN
BULL RANCH CREEK
BRIDGE ST
DOG CREEK
SUNRISE CREEK
I-80 BRIDGE

Along the north bank of the Truckee River, directly opposite the proposed overflow area, is the relatively new Cottonwood Park. Upon examination of the river and park in that area, it was observed that portions of the bicycle path along the river are well within the flood plain of the Truckee River. Debris, probably from a recent high flow in December 1981, has been deposited along the levee and bike path to within 3 feet of the top of the north bank levee. A tremendous amount of commercial development and warehousing is located just north of this levee, east of McCarran Lane, and south of Glendale Boulevard. If the Cottonwood Park levee were outflanked or overtopped, it appears that most of the commercial development would be flooded.

Proposed Overflow Area - There are a few existing residences and farm structures located along the south bank near the proposed overflow area. Were it not for these structures, this location would be a possible location for an overflow weir toward the south into the University Farms overflow area. In addition to the residences located on the south bank of the Truckee there is considerable residential development along the right bank of Steamboat Creek from the confluence with Boynton Slough upstream to Huffaker Hills. There is also a short leveed reach along Steamboat Creek on the right bank at the confluence with Boynton Slough. Flood flows would probably outflank this leveed area quite easily.

Prior to the field inspection, general information about the overflow area indicated that the elevations of McCarren Boulevard on the west side of the proposed overflow area and Pembroke Lane to the south were sufficiently high to provide an existing perimeter levee around the overflow area. The February 1982 field inspection of this area indicated that this is not the case. Both McCarran and Pembroke are almost at the same elevation as the overflow area, with an estimated maximum relief of only 2 to 3 feet. This would mean that substantial levee construction would be required to store the flood overflow waters. This apparent problem needs to be evaluated more thoroughly.

Sediment - Based on visual observations throughout the project area, there appear to be no obvious sediment related problems in the Truckee River or in the Truckee Meadows tributaries. Localized debris accumulation, beaver activity, and minor aggradation through the City of Reno were observed. These observations are confirmed by the biannual reports from the Carson-Truckee Water Conservancy District.

EROSION AND SEDIMENT PRODUCTION

General

In order to evaluate sediment sources and transport mechanisms along the Truckee River, the greater Truckee River Basin was subdivided into eight subbasins. Each subbasin was then examined individually and the contribution of sediment into the Truckee River from each was determined.

Sediment yield, sediment production, and sediment delivery into the Truckee River were determined by using data and computational procedures outlined in the following publications: USDA, SCS (1980), USDA, SEA (1978), Brown and Skau (1978), Borland (1977), USDA, SCS (1973), and USDA, SCS (1971).

There are two major kinds of soil erosion processes actively occurring in the Truckee River Basin: (1) water-induced erosion due to rainfall, snowmelt, and river mechanics, and (2) wind-induced (aeolian) erosion. Due to generally low precipitation, wind erosion may be a problem associated with construction and cultivation activities in Southwest Reno. Methods of computing wind-induced soil losses are outlined by the USDA, SCS (1976 and 1980). However, on a mean annual basis the total sediment yield and delivery into the Truckee River due to wind erosion may be small compared to other water-induced sources. For the purposes of this report, the total sediment production for subbasins in the southwestern portion of the Truckee River Basin were adjusted upward to reflect sediment contributions due to aeolian processes.

Measured information reported by Brown and Skau (1978), the USGS (1978) and the USDA, SCS (1973) have been used exclusively to prepare this report.

Analysis of Contributing Watersheds

In general, the dominant landforms in the basin were created by a granitic batholith (a plutonic intrusion resulting from magmatic processes which occurred millions of years ago) overlain by igneous volcanics and reshaped by faulting, exfoliation and glacial activity. Basin complexity is also enhanced due to large climatic variations (wind speed, temperature and precipitation) associated with the location and topographic relief of the Sierra Nevada Mountains located along the western boundaries of the basin. Accordingly, four major topographic provinces can be identified with the project area: (1) the Truckee River flood plain and related terrace areas (located in the northwestern part of the Truckee Meadows), (2) piedmont slopes, (3) intermontane basins such as Sun Valley, Lemmon Valley, and Panther Valley, and (4) the rugged mountainous regions primarily along the western borders of the basin. These generalized areas are shown in Figure 2. Detailed discussion of the characteristics and significance of each of these geologic provinces is presented in the "Reno Folio" by the Nevada Bureau of Mines and Geology (1976).

Figure 3 presents a schematic diagram of the Truckee River Basin and its contributing watersheds. The following discussions will present results from the sediment investigation for each contributing watershed.

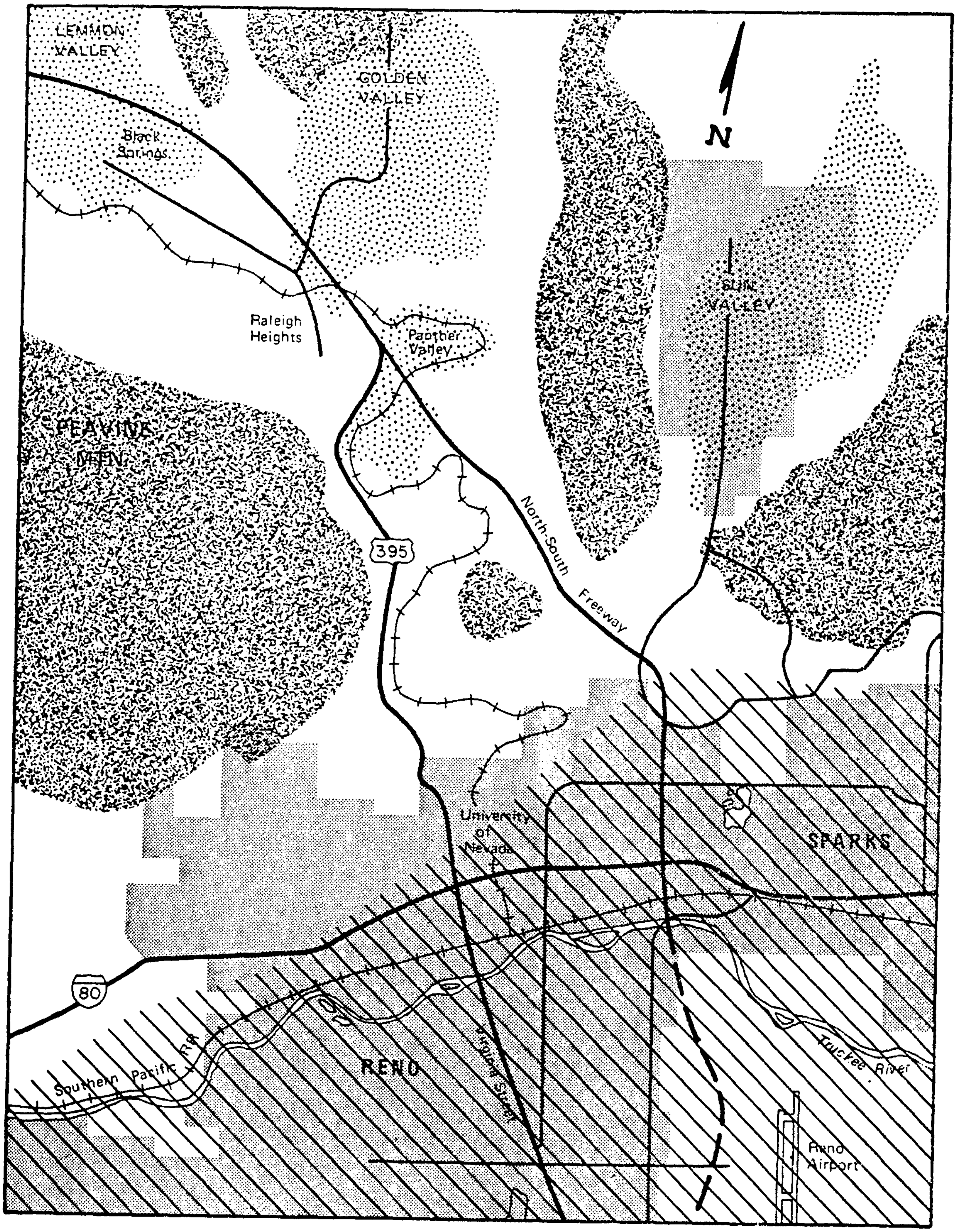


FIGURE 2 Major topographic provinces within the Reno quadrangle. The Truckee Meadows province is shown by the diagonal line pattern, the intermontane valleys are indicated by the coarse pattern of dots, and mountainous areas by the heavy irregular pattern. The white areas remaining between these three provinces mark the locations of piedmont slopes.

(From Nevada Bureau of Mines and Geology, 1976)

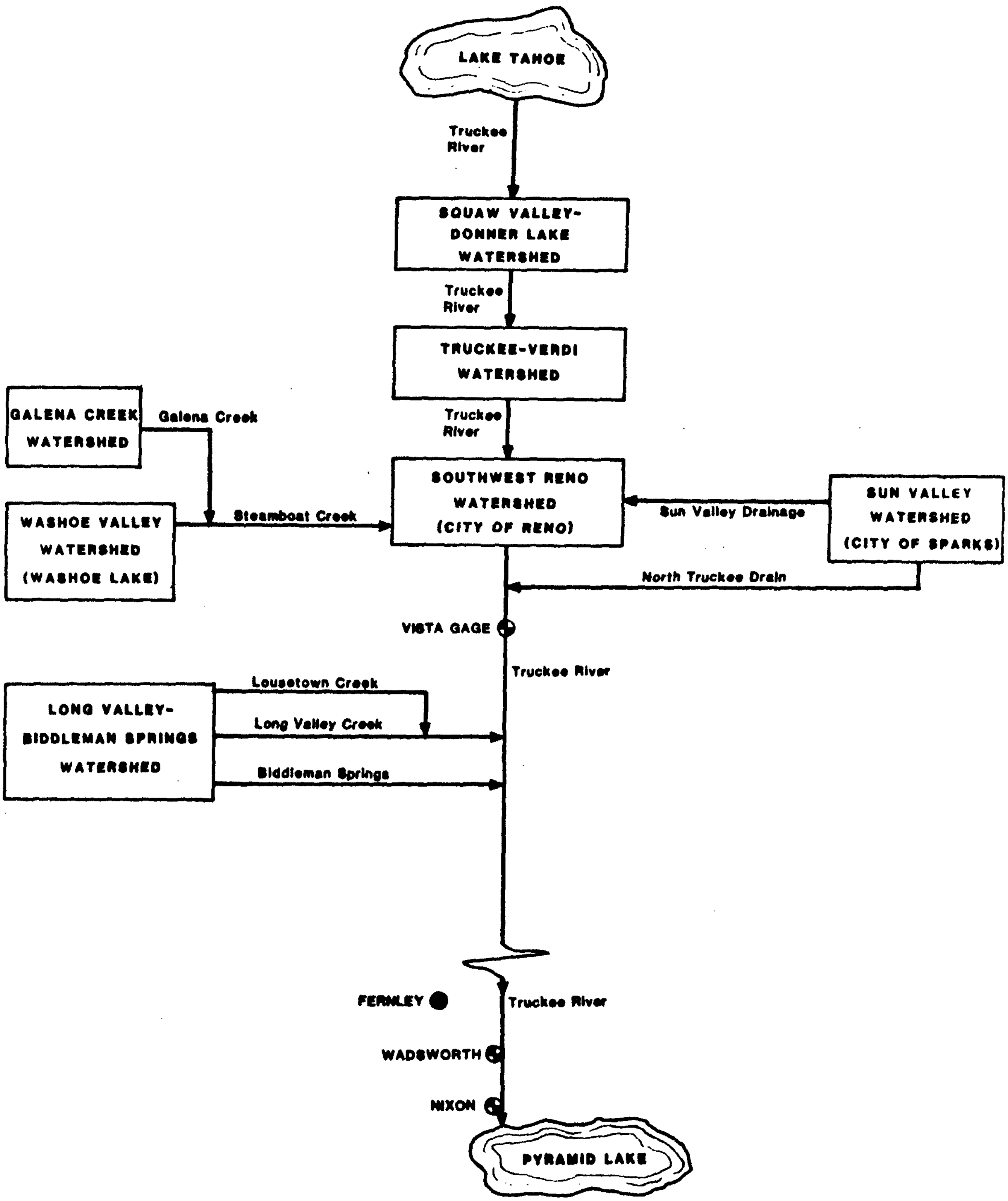


Figure 3

Runoff and Sediment Contributing Watersheds for the Truckee River

The entire Truckee River Basin drainage boundary was previously delineated in Chart 1. For the purposes of this investigation, however, those areas located in the upper half of the basin above Vista are of primary concern. The specific project reach extends from Verdi to Vista along the Truckee River. Therefore, only the six watersheds above Vista and the Long Valley-Biddleman Spring watershed below Vista (see figure 3) will be considered herein.

Squaw Valley - Donner Lake Watershed - This watershed includes all the drainages into the Truckee River, on both sides of the river, between the outlet at Lake Tahoe and Truckee, California. Figure 4 (from USDA, SCS, 1973) shows this watershed and the contributing drainages. Drainages from the west include Bear, Squaw, Pole, Deep, Silver, and Cabin Creeks while Deer Creek is the only significant drainage from the east. Other streams include Donner, Cold, Billy Mack, and Trout Creeks.

Several of these creeks have a history of carrying large amounts of debris and sediment during periods of high flow. The most active creeks are Cold, Silver, Pole, and Bear Creeks (USDA, SCS, 1973). Large gravel piles, rocks, and sandbars are located along the lower reaches of these creeks, as well as at their mouths. Cold Creek is perhaps the largest sediment producer in this watershed. It has created a large sediment and rock delta deposit immediately above the Cold Creek junction with Donner Creek which flows into the Truckee River at Truckee, California (USDA, SCS, 1973).

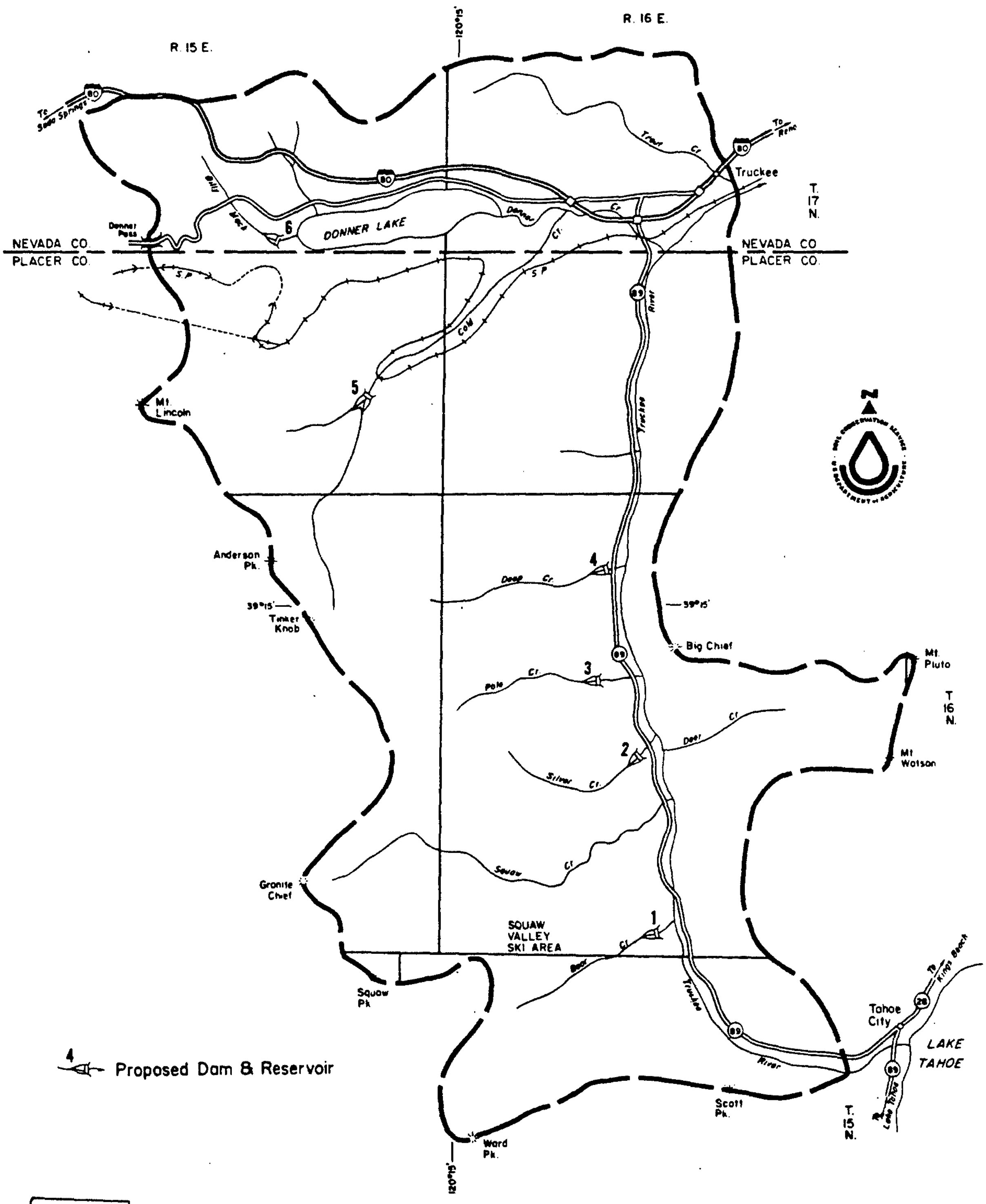
Timber cutting, sheep grazing (until recently), road and housing construction, and recreational developments such as ski resorts have all contributed to an increased erosion and sediment yield from this watershed. Mean annual precipitation ranges from 75 inches to 35 inches from the western most portion of the watershed to the eastern regions near Truckee, respectively. Most of this precipitation falls as snow in the winter months, but spring and summer thunder storms are also common. As a result, the Squaw Valley-Donner Lake Watershed is the principal source of the damaging Truckee River flood flows that still affect the Reno-Sparks area (USDA, SCS, 1973). To help reduce flood discharges, several flood control and power structures that have been placed on the Truckee River and on some of the drainages entering the Truckee River (see Chart 1).

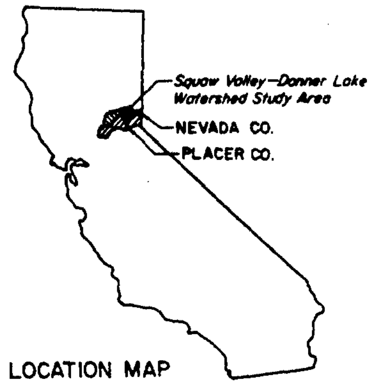
Based upon USDA, SCS (1973) measurements and soil loss and sediment production computations, the estimated annual sediment yield to the Truckee River from the lower portion of the watershed is 16,400 tons (13,500 cubic yards) per year.

The majority of the soils in and adjacent to the Truckee River were derived from silty sand, sandy gravel, sand, gravel, cobbles, and boulders. Deposits of larger sized materials are found farthest upstream and decrease in size downstream (toward the east). Based on this observation and on the soils and geologic reports by SPK (Sept., 1981), the Nevada Bureau of Mines and Geology (1976), and Technical Release No. 12 by the USDA, SCS (1975), the average submerged density of bed materials typically found at the downstream end of the Squaw Valley-Donner Lake Watershed is 90 pounds per cubic foot. Using this value as an approximate density for delivered sediment materials, and estimating the watershed area to be 68.8 square miles, the average annual sediment yield from the watershed is approximately 0.12 AF/sq.mi./year.

U. S. DEPARTMENT OF AGRICULTURE

From:
SOIL CONSERVATION SERVICE (1973)





LOCATION MAP

FIGURE 4

SQUAW VALLEY—DONNER LAKE WATERSHED STUDY AREA

NEVADA AND PLACER COUNTIES, CALIFORNIA

JANUARY 1973

1 0 1 2 3 MILES
SCALE 1:126,720

M7-0-22756-L

Truckee-Verdi Watershed - This study area includes the reach of the Truckee River between the cities of Truckee and Reno, and includes all the tributary drainages on both sides of the river between those points. Figure 5 (from USDA, SCS, 1973) shows the watershed and contributing drainages. The main drainages from the south and east include Martis, Juniper, Gray and Bronco Creeks. Drainages from the north and west include Bull Ranch, Prosser and Dog Creeks, and the Little Truckee River.

Four flood control reservoirs exist in this watershed. They include Boca, Stampede, and Prosser Reservoirs on the North side of the Truckee River and Martis Creek Reservoir on the south side of the Truckee River. These reservoirs have helped to decrease flood flows through Reno. They have also decreased the sediment load to the Truckee River from the fire- and timbering-damaged watersheds located above the reservoirs.

Gray, Bull Ranch, Bronco, and Dog Creeks are considered (USDA, SCS, 1973) to be the three major sediment producers to the Truckee River for that reach of river above Reno. High sediment loads from this area are a result of a history of several destructive fires, extensive timber cutting and poor range management practices. Bull Ranch, Mitchell and Gray Creeks are severely eroding, particularly in their lower reaches (USDA, SCS, 1973).

The present estimated annual amount of sediment delivered to the Truckee River from this watershed is 49,500 cubic yards or 60,200 tons (assuming a representative submerged sediment density of 90 lbs/cubic ft.). This represents an adjusted subbasin sediment yield of approximately 0.10 AF/sq.mi./yr. This yield is reduced by the presence of the four previously mentioned reservoirs in the watershed. Therefore, even though rates of surface erosion and soil losses may be quite high within the watershed, the actual amount of sediment delivered to the Truckee River, as well as the corresponding adjusted sediment yield, will be much less. If these reservoirs did not exist, the average annual sediment yield to the Truckee river would be between two and three times its current rate.

Galena Creek Watershed - Figure 6 shows the Galena Creek Watershed which is located about 15 miles south of Reno on the east slope of the Carson Range. Three main tributaries to Galena Creek are Jones Creek, South Fork, and Black's Fork. As shown in Figures 3 and 6, Galena Creek flows into Steamboat Creek about 8 miles south of Huffaker Hills. Steamboat Creek then flows north into the Truckee River near Vista.

Galena Creek drains to the Mt. Rose area which is a complex geologic assemblage of volcanic and granitic rocks with glacial features and pediment remnants on the very steep mountain slopes. The dominant soils are a mixture of coarse textured granitic rocks and fine loamy piedmont materials. Sandy and coarse loamy materials are also found along the lower slopes of the watershed (USDA, SCS, 1973 and 1976). An estimated average submerged sediment density is 95 pounds per cubic foot.

Forest fires and past logging activities have damaged the watershed. The Soil Conservation Service (1973), the Forest Service, and Army Corps of Engineers have all participated in soil conservation projects along Galena Creek and its drainages. Erosion control has included hillside contouring, gully-plugging, and planting of native and adoptive species of grasses.

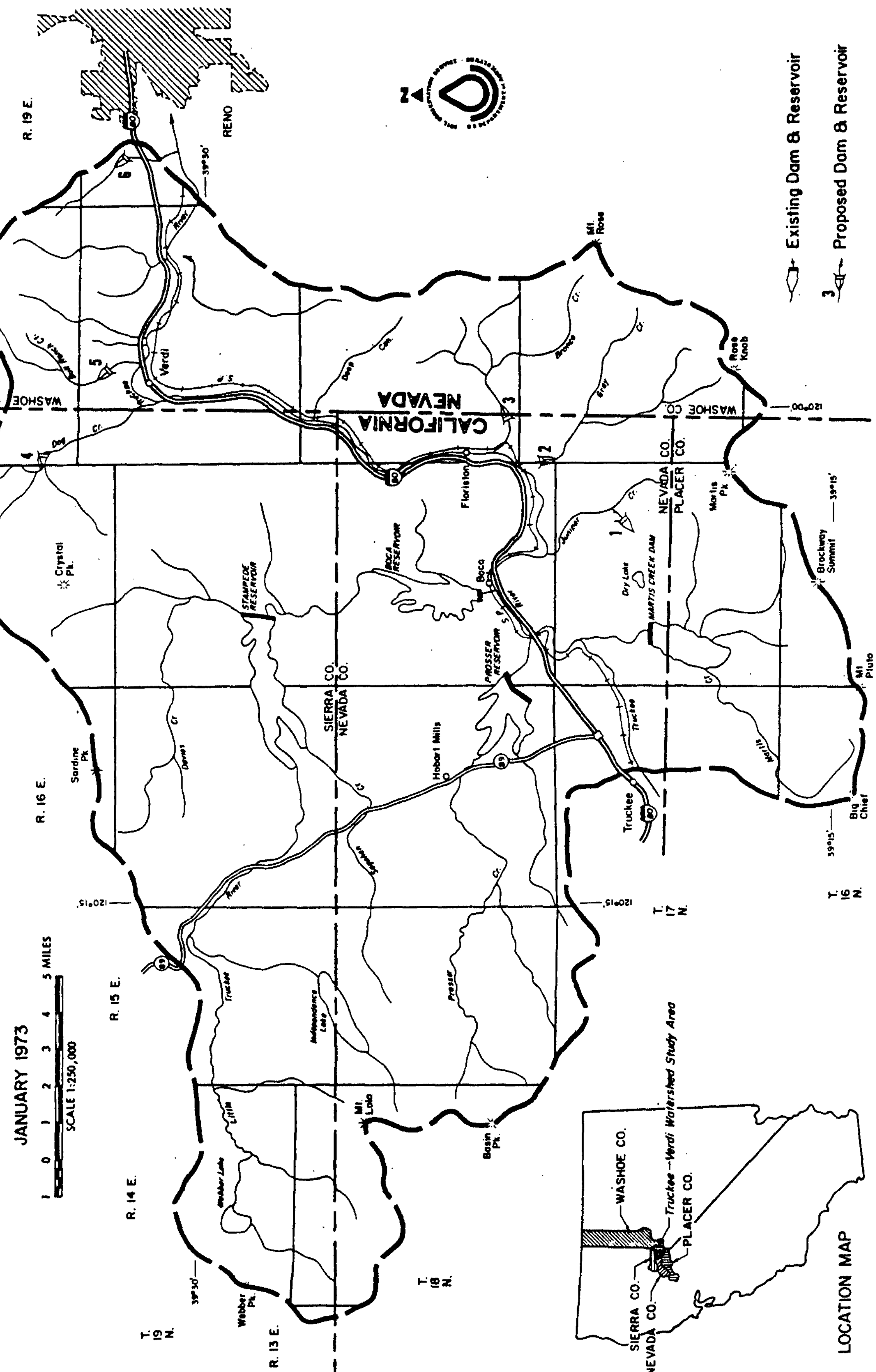


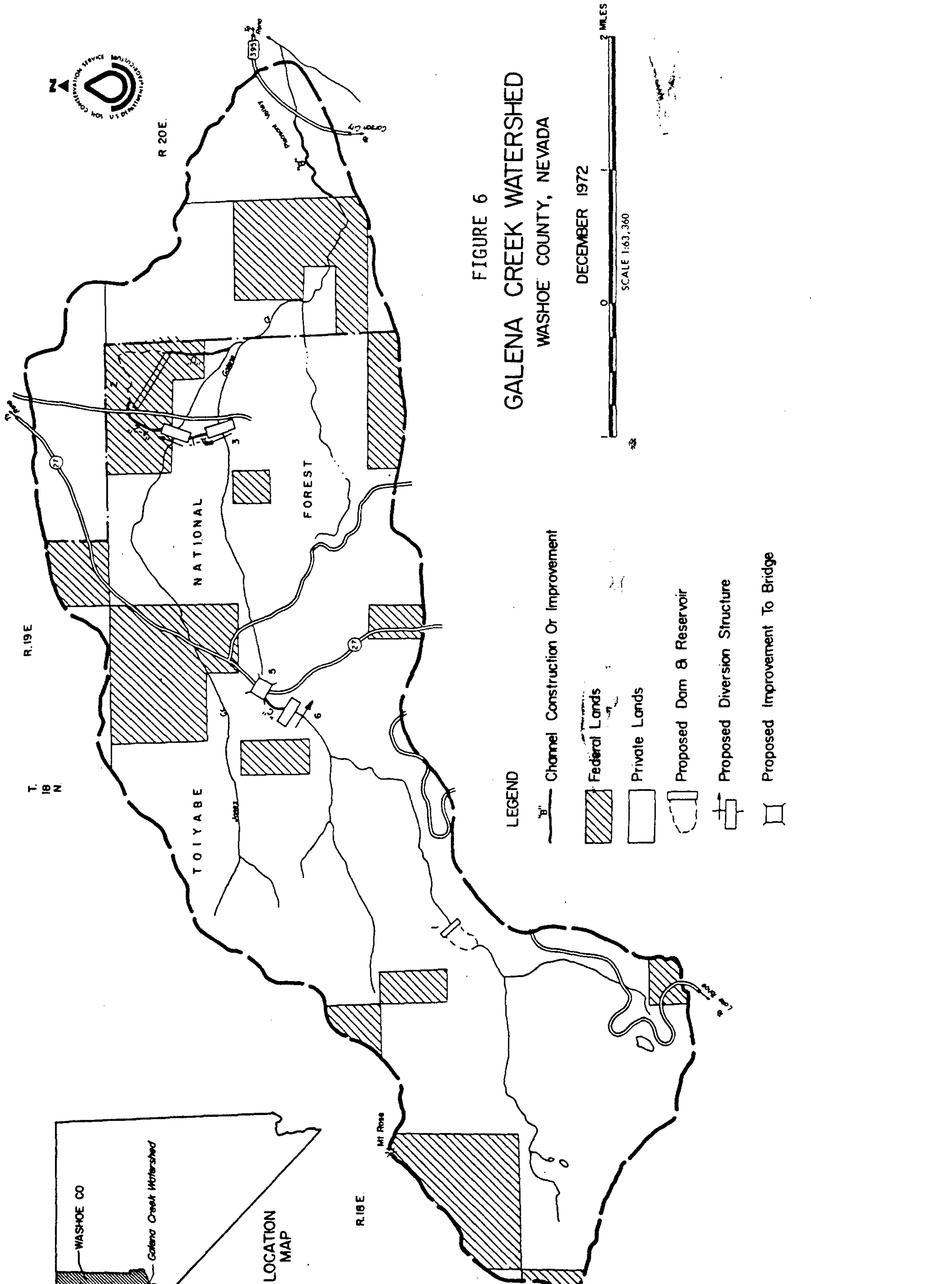
FIGURE 5

TRUCKEE—VERDI WATERSHED STUDY AREA
NEVADA, PLACER, AND SIERRA COUNTIES, CALIFORNIA,
AND WASHOE COUNTY, NEVADA

From:

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE (1973)



M7-0-22754-L

An average sediment production rate of 0.2 AF/sq.mi./yr. is estimated for this watershed. This represents 10,700 tons or 8,800 cubic yards of sediment per year. The SCS (1973) estimates that approximately one half of the sediment produced in the Galena Creek watershed is deposited in Pleasant Valley prior to reaching Steamboat Creek. Therefore, a conservative estimate of the amount of sediment entering Steamboat Creek from the Galena Creek Watershed is 5,350 tons/yr or 4,400 cu.yds/yr. During a particularly wet year, less deposition will occur in Pleasant Valley, and a greater amount of sediment will be delivered to Steamboat Creek.

Washoe Valley Watershed - The Washoe Valley Watershed (see Figure 7) is located approximately 14 miles south of Reno in the extreme southern portion of Washoe County. The Carson range is on the west, the Virginia range is on the east and the Washoe and Little Washoe lakes are located in the central valley. Steamboat Creek is the main drainage out of the watershed; it empties into the Truckee River after flowing through the southern portion of the Southwest Reno Watershed (see Figure 3).

Agriculture is the primary economic activity in the watershed. Recent urban development is changing parts of the watershed into residential and recreational satellites for Reno and Carson City.

The meadowlands portion of the watershed has a long history of flooding problems resulting in large deposits of debris and sediment. Sediment deposition is occurring in the meadow areas of Washoe Valley, Pleasant Valley, and Steamboat Valley. Sediment collects in irrigation ditches, canals, and along roads and highways. Sediment flowing into the Washoe and Little Washoe Lakes increases the turbidity of the water and affects some of the water quality characteristics of the lakes.

Ophir, Browns, Lower Franktown, and Jumbo Creeks are the major sediment carrying creeks in the watershed. Ophir Creek can produce very large amounts of sediment at times. It is situated along the southeastern drainage of Slide Mountain, which has a history of periodic landslides and mass wasting.

The SCS (1973) estimated the annual sediment production from the areas around Little Washoe and Washoe Lakes was 15,400 cubic yards (18,500 tons). Due to Washoe and Little Washoe Lakes and the flat relief in the meadows area, approximately 72 percent of this sediment material is deposited and never leaves the basin. Therefore, the total estimated amount of sediment leaving the basin and entering Steamboat Creek is 4,400 cubic yards per year or about 5,100 tons per year (USDA, SCS, 1973). This represents an average sediment yield of 0.03 AF/sq.mi./yr.

Sun Valley Watershed - Figure 8 shows the Sun Valley Watershed which is located northeast of Reno along the north side of the Truckee River. The watershed has no perennial streams. However, the North Truckee Drain, Sun Valley Wash and Orr Ditch carry ephemeral flows during the winter and spring months. The central drainage flows through the community of Sun Valley and the City of Sparks into the Truckee River near Vista. The watershed consists primarily of valley bottomland, the Sparks flood plain adjacent to the Truckee River, and some rolling hills in the northern portion of Sun Valley.

U. S. DEPARTMENT OF AGRICULTURE

From:
SOIL CONSERVATION SERVICE (1973)

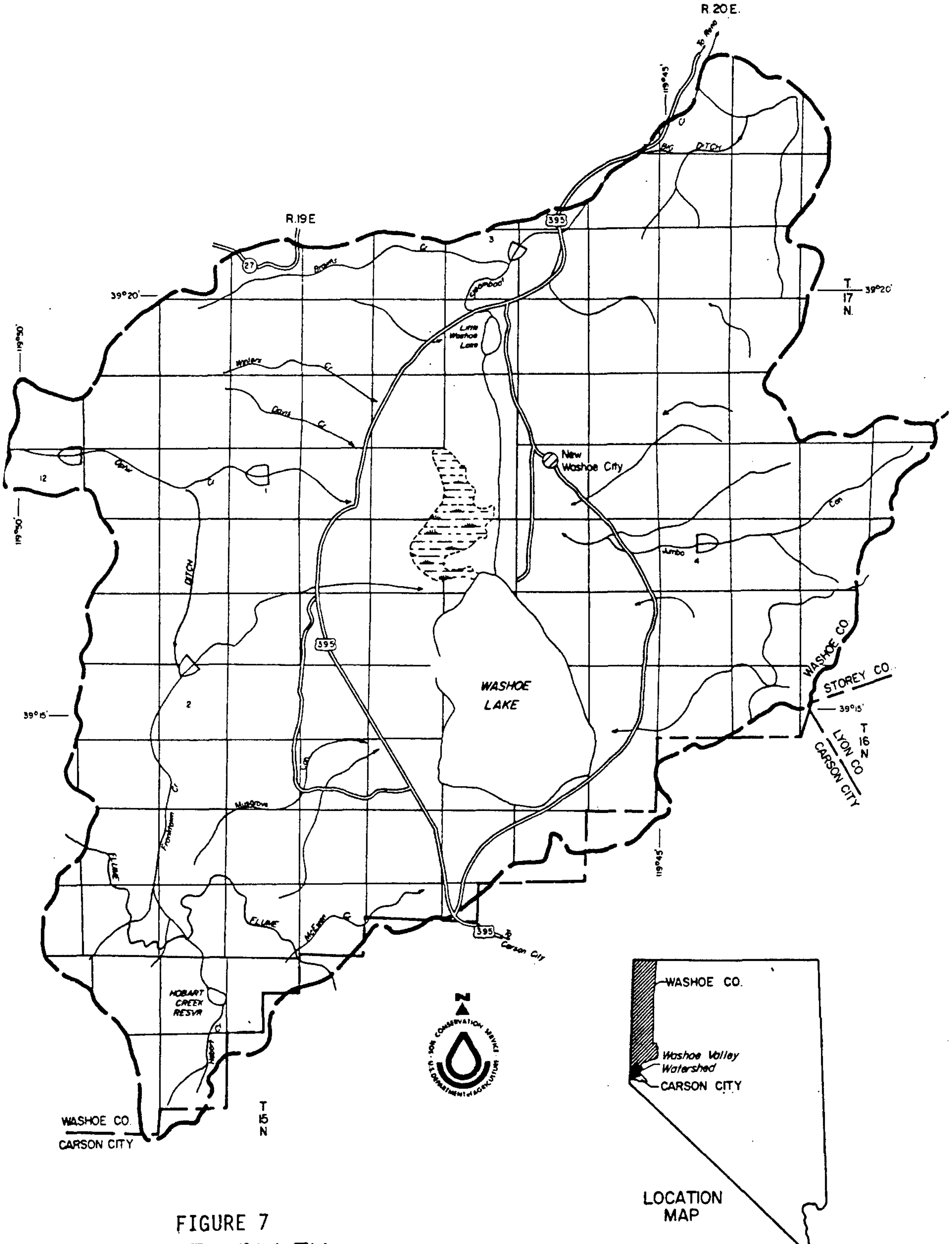


FIGURE 7
WASHOE VALLEY
WATERSHED STUDY AREA
CARSON CITY & WASHOE COUNTIES, NEVADA

DECEMBER 1972

1 0 1 2 3 MILES
SCALE 1:126,720

LEGEND

Proposed Dam & Reservoir

M7-0-22751-L

U. S. DEPARTMENT OF AGRICULTURE

From:
SOIL CONSERVATION SERVICE (1973)

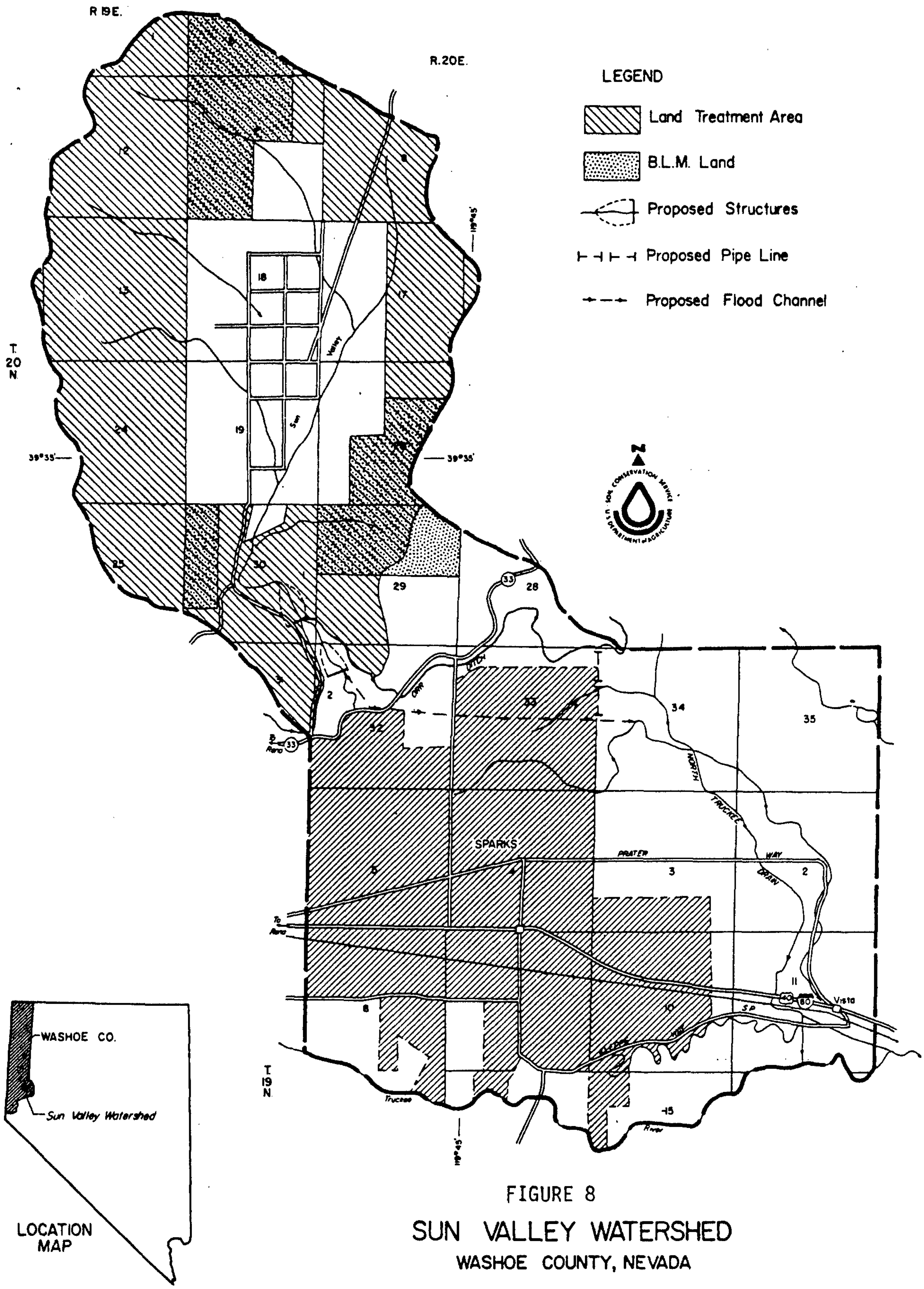


FIGURE 8

SUN VALLEY WATERSHED

WASHOE COUNTY, NEVADA

DECEMBER 1972

SCALE 1:62,500

M7-0-22753-L

The watershed is quite arid, receiving only 7 to 10 inches of rain per year. Basin soil types are generally composed of piedmont slope soils, with clayey and loamy soils dominating the flood plain areas in Sparks.

Residential housing and extensive "free-port" warehousing are the dominant land uses in the watershed. Southern Pacific Railroad and the Richfield Oil Company operate a large oil storage facility in Sparks.

According to SCS (1973) reports, slight to severe erosion is present in Sun Valley with most of the problems occurring in the upland Sun Valley drainages as gully erosion. Over grazing and past fires have destroyed much of the perennial vegetation.

Flooding has occurred many times in the past, especially in the Sparks area immediately adjacent to the Truckee River. This area has always been located within the Truckee River flood plain. However, residential and commercial development is still occurring.

Even though sediment is produced throughout the upper regions of the watershed, deposition occurs all along the Sun Valley Wash and upstream in the northern sections of Sparks. The estimated annual sediment production being delivered to the lower end of the watershed and ultimately the Truckee River is approximately 1,480 cubic yards or 1,700 tons (USDA, SCS, 1973). This represents a basin averaged sediment yield of .04 AF/sq.mi./yr.

Southwest Reno Watershed - Figure 9 shows the Southwest Reno Watershed which is located in the southern portion of Washoe County and includes the City of Reno, the Truckee Meadows area, and most of the drainages immediately south of Reno. Major drainages include Hunter, Alum, Evans, Dry, Thomas Whites, and Bailey Canyon Creeks. Bailey Canyon originates in the Virginia Mountains while the other drainages flow northeast from the Carson Mountain Range. Several of these ephemeral creeks eventually enter the Truckee River directly, through flood control and irrigation networks, or from drainage entering Steamboat Creek.

This watershed varies a great deal in topographic relief from high peaks above 10,000 feet in the Sierra Nevada Mountains to broad, relatively flat bottomlands and flood plains in the Truckee Meadows area at an elevation less than 5,000 feet. As a result of this topographic diversity, the climatic conditions also vary a great deal. Annual precipitation varies from approximately 40 inches near Mt. Rose to less than 7 inches near Reno.

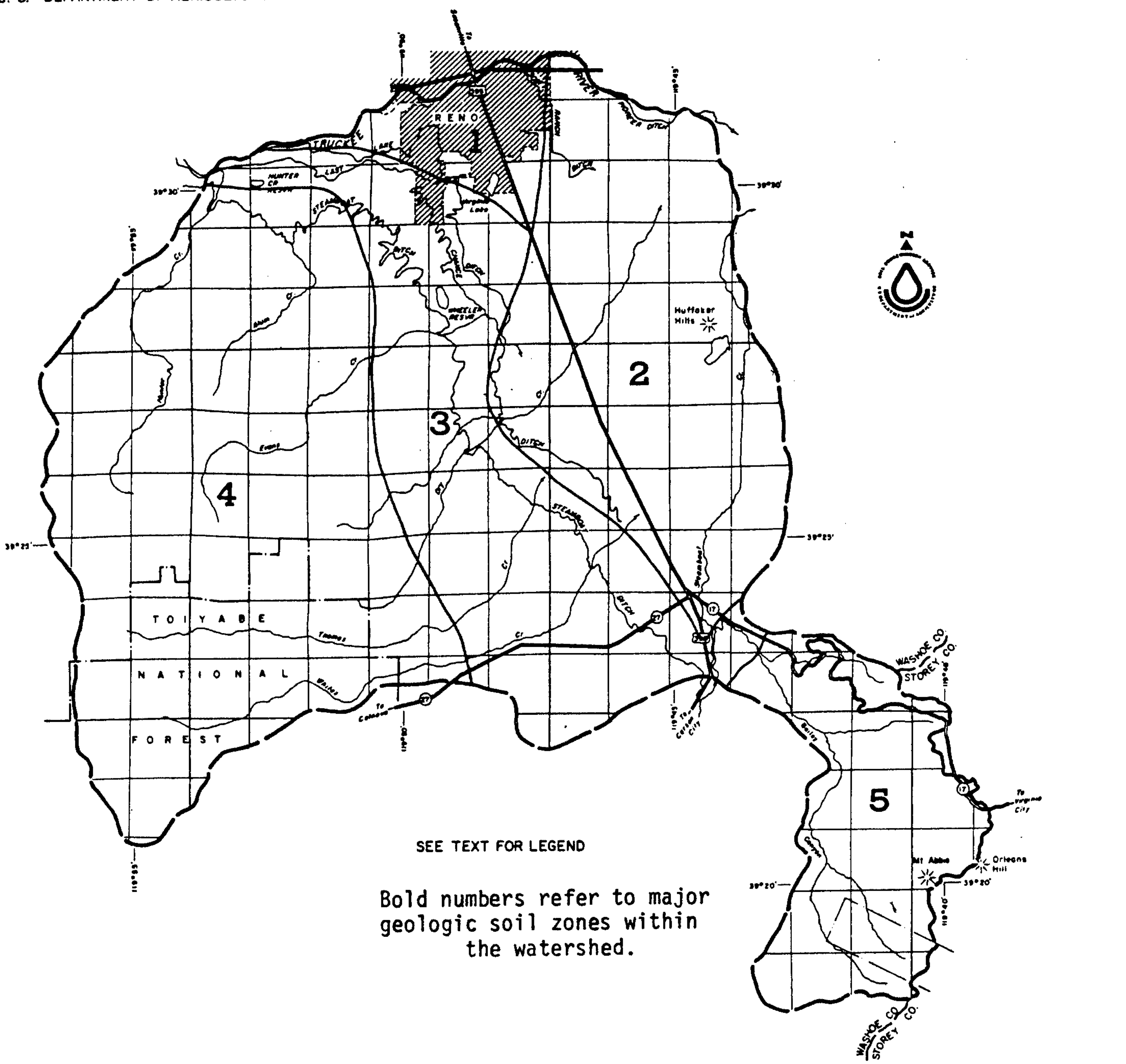
Land use is almost as varied as the topography, ranging from urban and rural housing, light and heavy industry, gaming, and retail businesses near Reno to grazing and recreational uses in the rugged Toiyabe National Forest. The Reno airport is located near Truckee Meadows. It is the only major airport in northern Nevada.

Figure 9 identifies five major soil zones within the watershed (USDA, SCS, 1973). Zone 1 (Central Reno) is comprised primarily of Pleistocene glacial outwash with subsoils of clays and clayey loams. Scattered stones, cobbles, and some boulders are found in the deposits. Zone 2 (Truckee Meadows) is comprised of recent alluvium made up of fine loamy soils with high organic components. Zone 3 (Carson Range piedmont slope) consists primarily of gently sloping piedmont soils. Zone 4 (Carson Range) consists of a

From:

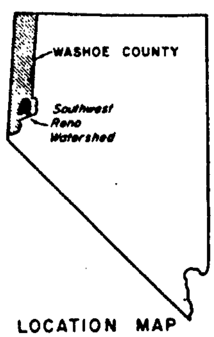
U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE (1973)



SEE TEXT FOR LEGEND

Bold numbers refer to major geologic soil zones within the watershed.



LOCATION MAP

FIGURE 9

SOIL AND GEOLOGY ZONES

SOUTHWEST RENO WATERSHED

WASHOE COUNTY, NEVADA

JANUARY 1973

1 0 1 2 3 MILES

SCALE 1:156,250

M7-0-21673A-L

large variety of soils and soil slopes, while Zone 5 (Bailey Canyon) consists ot very steeply sloped acidic soils that are highly erodable.

Zone 2 and most of Zone 1 are areas where sediment actively deposits. Zones 4 and 5 have the most active erosion in the watershed. Materials originating in Zones 4 and 5 generally travel through Zones 2 and 3, where some material is deposited prior to reaching the Truckee River.

Periodic flooding and sediment damage often occur in the lowland areas of the watershed and along the major watercourses as a result of wet mantle, dry mantle, and rain-on-snow or frozen ground storm events. A chronology of major flood events that have occurred in the Southwest Reno Watershed is presented in the "Truckee River Watershed Investigation" (USDA, SCS, 1973).

Major sediment sources are eroding areas located on moderately to steeply sloping hillsides in Zones 4 and 5. Eroded sediment is deposited all along the drainages from Zones 4 and 5 through 3 and 2 on the way through the Truckee Meadows to the Truckee River. It is estimated that approximately 24,200 cubic yards (27,800 tons) of sediment are delivered to the Truckee Meadows each year, with approximately 12,000 cubic yards (13,900 tons) reaching the Truckee River. This represents an annual sediment yield to the Truckee Meadows of 0.11 AF/sq.mi./yr. and a yield to the Truckee River of approximately 0.06 AF/sq. mi./yr.

Long Valley - Biddleman Springs Watershed - Figure 10 shows these two watersheds. They are considered jointly here because they are similar. Located about 12 miles east of Reno, these drainages empty into the Truckee River below Vista. These watersheds are located below the project area being addressed by this report. However, it is felt important to present the sediment yield and production results for a representative watershed below Vista for comparison purposes. Borland (1977), the USDA, SCS (1980 and 1973), and Brown and Skau (1978) all suggest that sediment production is greater for those watershed areas draining into the Truckee River below Vista than above Vista.

The Long Valley-Biddleman Springs Watershed is a sparsely inhabited and arid region located directly south of the Truckee River in Storey and Lyon Counties below Vista. Mining, limited agriculture and grazing are the major economic activities in the area.

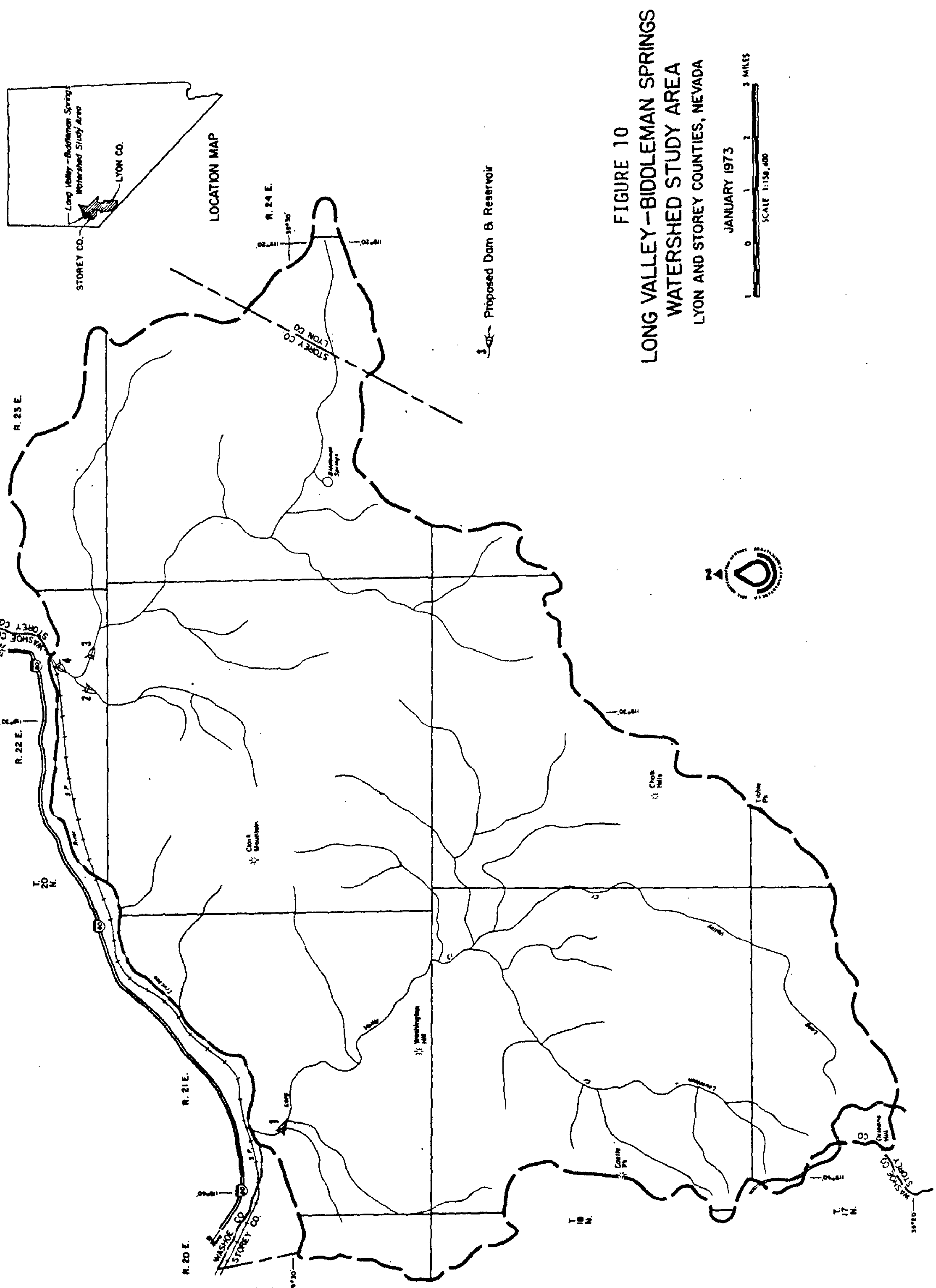
Varying amounts of erosion are reported throughout the watershed (USDA, SCS, 1973). Studies by the Soil Conservation Service (1973) and Borland (1977) indicate that Long Valley Creek (see Figure 10) is one of the highest sediment-producing tributaries along the Truckee River. It is estimated that Long Valley Creek delivers approximately 15,800 cubic yards (18,200 tons) of sediment into the Truckee River each year. Some of this sediment deposits along the channel bottom and flood plain of the Truckee, behind diversion structures, and some eventually into Pyramid Lake. The estimated annual amount of sediment being delivered to the Truckee River from the Biddleman Springs drainage is 9,100 cubic yards or about 10,500 tons (USDA, SCS, 1973).

For the combined watersheds this represents an average annual sediment yield of more than 0.09 AF/sq.mi./yr. However, this total average annual

From:

SOIL CONSERVATION SERVICE (1973)

U. S. DEPARTMENT OF AGRICULTURE



production rate can be exceeded by orders of magnitude by a single large flood event because the watershed is so unstable.

Basinwide Average Annual Sediment Production

Estimated average annual sediment production rates for each of the six contributing watersheds above Vista are summarized in Table 2. A total estimated sediment production from Lake Tahoe to Vista is approximately 122,700 tons per year (102,700 cu.yd./yr.). This is based on the assumption that all of the sediment delivered to the Truckee River from the contributing watersheds continues through the system without depositing. This represents a basinwide (for those contributing watersheds above Vista only) weighted average sediment yield of approximately 0.1 acre feet per square mile per year.

Figure 11 shows each of the watersheds and lists the estimated sediment production rate for each, as well as the total average annual sediment loads at Vista and Nixon. The production rates listed adjacent to each watershed is the estimated amount for that watershed alone. They are not cumulative amounts. Total amounts are indicated in brackets at Vista and Nixon. Borland (1977) estimated from measured data collected at Nixon that the total average annual sediment load passing Nixon was 275,000 tons per year (250,000 cu.yds./yr.). This is approximately twice the amount estimated for Vista. Reports by Borland (1977), USDA, SCS (1973, 1980), Brown and Skau (1978) and Glancy, et al. (1972) all suggest that the lower portion of the Truckee River Basin below Vista is a much higher sediment producer than the upstream portion. This may be a result of geologic characteristics, the lack of protective vegetation, and the varied climatic conditions throughout the area.

It should be noted, however, that the sediment production rates reported herein are only estimated amounts and need to be verified with field measurements and further study.

Estimated 100-year Flood Sediment Production

Estimation of sediment production and delivery due to intense rain storms is a difficult task due to many complicating factors. Such factors include climatic variability, differences in local and areawide geology, antecedent moisture content of the soil, river flow conditions, and the character and availability of surface and channel sediment prior to the event.

For the purpose of this reconnaissance-level investigation, estimated 100-year sediment production rates were developed in a very simple way. Estimated rates were generated by assuming that the average annual sediment production could be multiplied by a factor obtained from comparing expected magnitudes for single-storm erosion indexes with the average annual erosion index. Agriculture Handbook No. 537 (USDA, SEA, 1978) lists several expected single-storm erosion indexes that were computed for storm conditions that are likely to be exceeded once in 1-, 2-, 5-, 10-, and 20-year periods. An exceedance frequency curve was developed using the values listed in Tables 17 and 18 in AH No. 537 (USDA, SEA, 1978), and then the "100-year expected single-storm erosion index" was extrapolated from this plot. The ratio of the 100-year value to the average annual erosion index provided a

TABLE 2

Estimated Sediment Production Rates and Yields for Watersheds that Contribute to the Truckee River

Watershed	Approximate Drainage Area (sq.mi.)	Estimated Ave. Ann. Sediment Production (1) (tons/yr)x10^3	Estimated Ave. Ann. Sediment Production (1) (cu.yds./yr)x10^3	Estimated Ave. Ann. Sediment Yield to Truckee River (1) (AF/sq.mi./yr)	Estimated 100-yr Flood Sediment Production (2) (tons/STORM)x10^3	Estimated 100-yr Flood Sediment Production (2) (cu.yds./STORM)x10^3
Squaw Valley-Donner Lake	69	16.4	13.5	0.12	201.7	166.1
Truckee-Verdi	350	60.2	49.5	0.10	740.5	608.9
Galena Creek	20	5.4	4.4	0.14	65.8	54.1
Washoe Valley	100	5.1	4.4	0.03	62.7	54.1
Sun Valley	24	1.7	1.5	0.04	20.9	18.2
Southwest Reno	133	13.9	12.0	0.06	171.0	147.6
Estimated Channel Bed and Bank Erosion	--	20.0	17.4	--	246.0	214.0
Totals Estimated from this Study, Lake Tahoe to Vista						
Truckee River,(3)(5) Lake Tahoe to Vista	696 (sq.mi.)	122.7x10^3 (tons/yr)	102.7x10^3 (cu.yds./yr)	0.095 (4) (AF/sq.mi./yr)	1.51x10^6 (tons/STORM)	1.26x10^6 (cu.yds./STORM)
Totals Estimated by W. Borland (1977), Farad to Nixon Station						
Truckee River,(3)(5) Farad to Nixon	968 (sq.mi.)	250x10^3 (tons/yr)	227x10^3 (cu.yds./yr)	0.147 (4) (AF/sq.mi./yr)	3.08x10^6 (tons/STORM)	2.79x10^6 (cu.yds./STORM)
Totals Estimated by W. Borland (1977), Lake Tahoe to Nixon (near Marble Bluff)						
Entire Truckee River Basin, Lake Tahoe to Nixon (3)(5)	1900 (sq.mi.)	275x10^3 (tons/yr)	250x10^3 (cu.yds./yr)	0.082 (4) (AF/sq.mi./yr)	3.38x10^6 (tons/STORM)	3.08x10^6 (cu.yds./STORM)

(1) Values represent rates of production and yield based on the estimated amounts of sediment reaching the Truckee River from the entire watershed each year.

(2) Product of estimated average annual sediment production rate and an estimated 100-year flood erosion index factor.

(3) Assumes all the sediment delivered to the Truckee River is transported through the system without depositing during high flows.

(4) Area weighted basin average annual yield.

(5) Includes channel bed and bank erosion

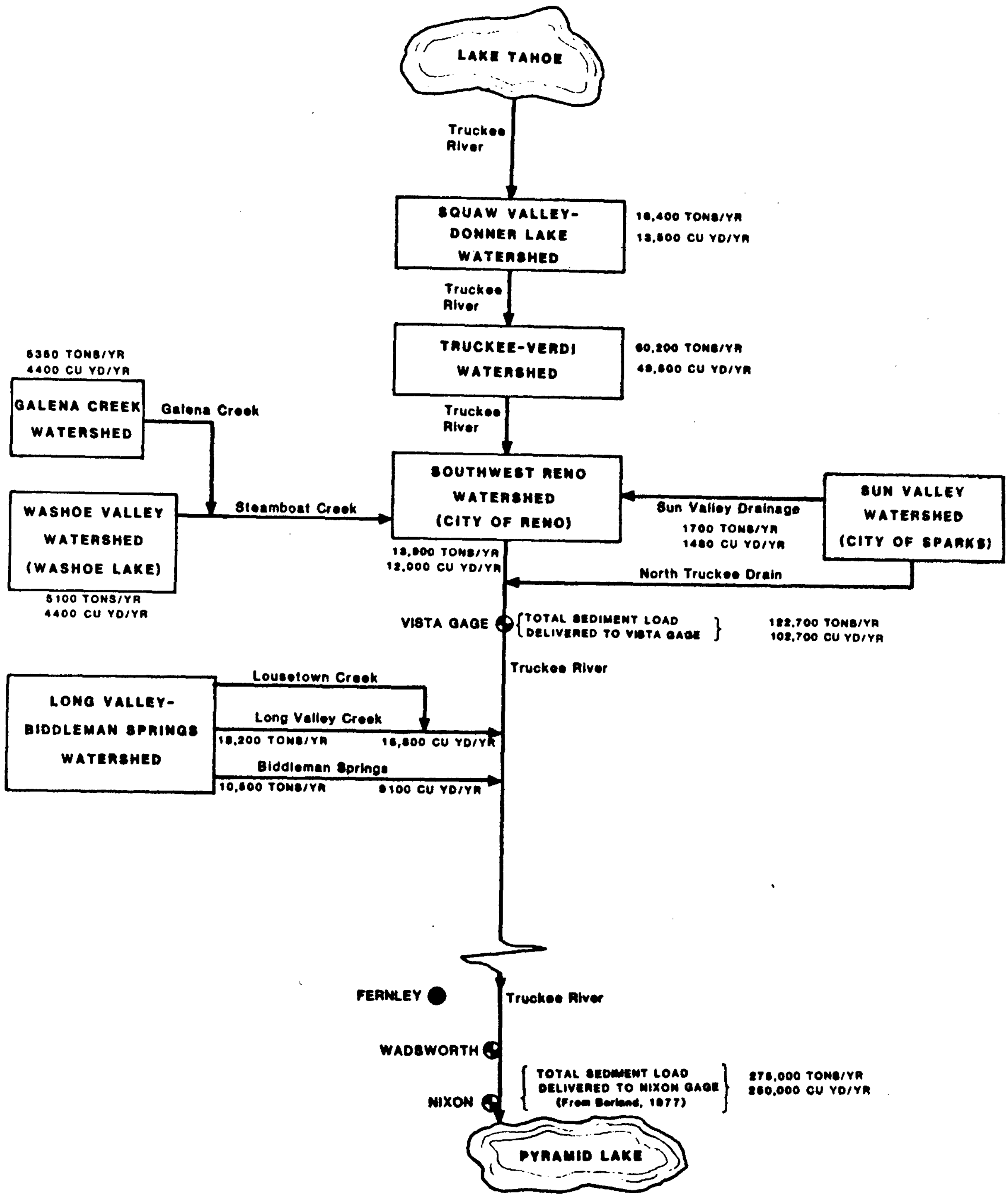


Figure 11

Runoff and Sediment Contributing Watersheds for the Truckee River With Their Estimated Average Annual Sediment Production Rates

multiplication factor of approximately 12.3. This factor was used to multiply the average annual sediment production rates to produce estimated 100-year storm sediment productions of 1.51×10^6 tons and 1.26×10^6 cubic yards total load in the Truckee River passing the Vista gage. Table 2 also presents estimated basinwide sediment production and yield values that were developed by Borland (1977).

Comparison of Sediment Production Rates With Results From Other Studies

The sediment production rates and sediment yields presented in Table 2 are comparable to computed and measured values presented by Borland (1977), Glancy, et al. (1972), Brown and Skau (1978), and the USDA, SCS (1973 and 1976). Borland (1977) computed a total average sediment load at Marble Bluff of 275,000 tons per year (250,000 cu.yds./yr). For flows above Farad the total load was estimated to be 25,000 tons (22,700 cu.yds.) and for the entire lower basin below Farad, the total load was estimated to be 250,000 tons per year (227,000 cu.yds./yr).

As indicated in Table 2, these basin-averaged production rates represent unit sediment yields of from 0.08 to 0.15 acre feet per square mile per year. Other investigations using different data for different periods of record developed estimated basinwide unit sediment yields at Nixon ranging from 0.05 to 0.23 AF/sq.mi./year. Other studies for the upper basin estimate unit sediment yield to be approximately 0.014 to 0.20 AF/sq.mi./year.

Estimation of Sediment Deposition Potential In the Reno and Truckee Meadows Areas

The amounts of sediment presented in Table 2 are total load estimates. Only a portion of these materials will have the potential to deposit in the project area. Based on the local soil types identified within the watershed, it is estimated that the materials delivered to the Reno and Truckee Meadows areas will be composed of approximately 2 percent gravel, 48 percent sand, 33 percent silts, and 17 percent clays. This composition of materials is similar to Borland's (1977) estimate. Therefore, based on these estimated grain size distributions, the potential total average annual amount of sediment available for deposition in the project area would be approximately 50 percent of the total production. Reno could potentially receive as much as 50,000 tons (43,500 cubic yards) of sediment deposits during an average year. Truckee Meadows could receive 61,400 tons (51,300 cubic yards) of sediment. This estimate assumes that silts and clays will move through the area without depositing. This assumption needs to be checked carefully, however. Using the same material distribution and assumptions, the potential 100-year flood deposit is 755,000 tons (630,000 cu.yds.) in the Truckee Meadows area and approximately 615,000 tons (536,000 cubic yards) in Reno.

Effects of Proposed Project Features on Sedimentation

General Project Features - A channel modification plan has been developed by the Sacramento District Corps of Engineers (USACE, SPK, 1980a and b). The purpose of their plan is to improve the project reach of the Truckee River so that it will contain the design discharge and provide adequate freeboard along the river banks and under bridges. Plate 6 from the hydrology report by SPK (1980a) presents the major features of the channel modification plan. The plan includes: modifying the cross section of portions of the existing channel by

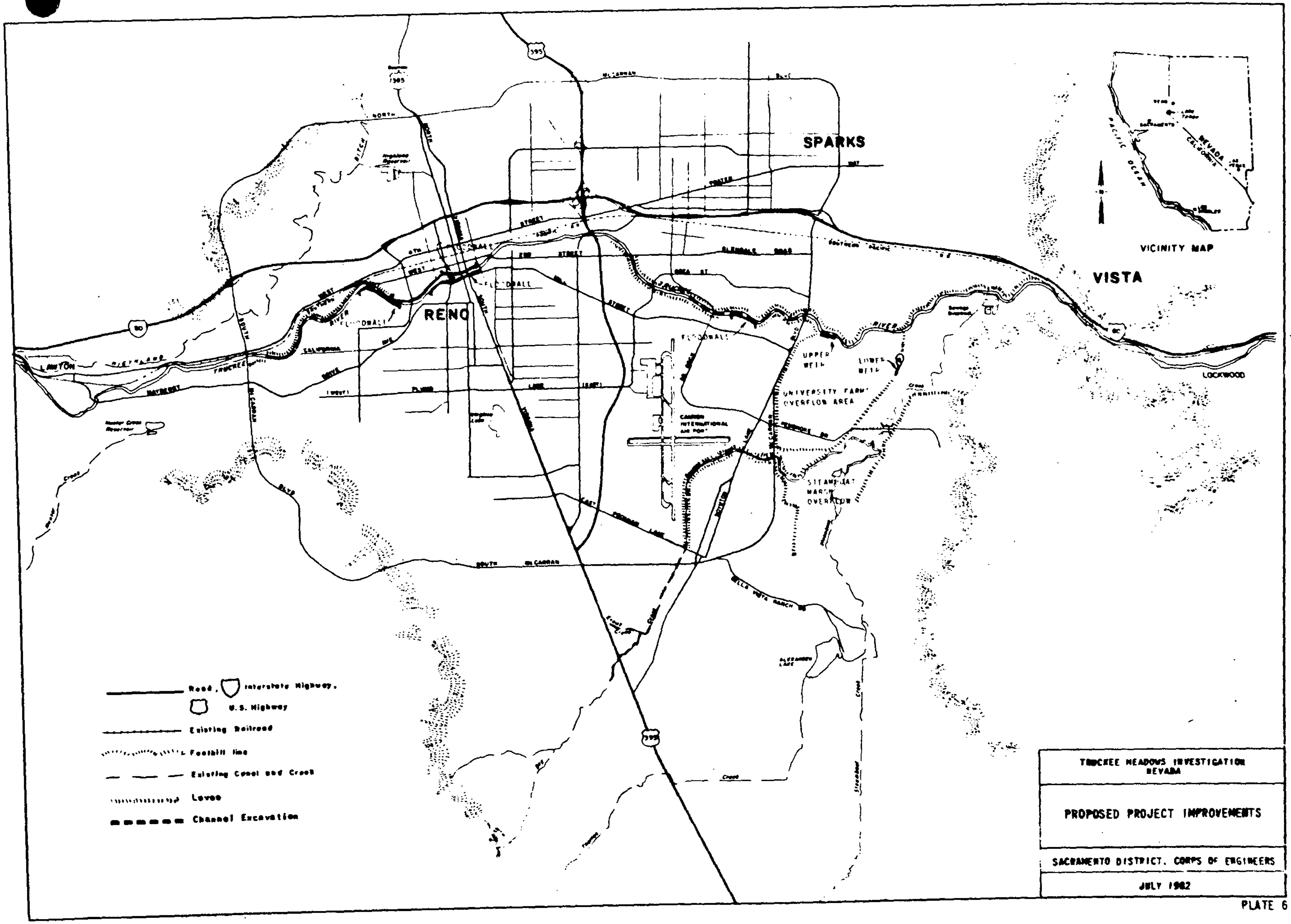


PLATE 6 (SPK, 1980)

increasing the flow area and elevating the top of the banks; removing, replacing, or modifying bridge crossings; relocating utilities that cross the river; clearing portions of the channel to reduce its hydraulic roughness; removing or modifying diversion structures in the river; modifying drain inlets along the river banks, and constructing a flood water overflow detention area near University Farms, south of the Truckee River and bounded by Boynton Lane, Pembroke Drive, and Steamboat Creek.

Discussion of Potential Sediment Problems - The Truckee River is a "pool and riffle" type river and has a great deal of hydraulic diversity. The hydraulic features and associated sediment transport capacity of the River are, therefore, a mixture of several contributing factors. Major factors include: energy slope and channel bed slope, effective channel roughness, existence of contracting or expanding flow areas, in-channel grade control or diversion structures, inflows or diversions of significant magnitude, and the character and availability of bed and suspended sediment materials.

Changes that would significantly affect any one of these factors would cause the channel hydraulics and sediment transport characteristics of the river to become readjusted near the disturbance. Depending upon the magnitude and duration of the disturbance, the apparent character of the river may or may not change significantly. Leeds, Hill and Jewett, Inc., (1982) have used computer program HEC-2 to evaluate the hydraulic conditions upstream from the Highway 395 bridge that will result from the proposed channel modifications. They also state in their report that they have computed the maximum flow velocities at critical channel locations and calculated the associated bed shear stresses at those locations. According to their preliminary report (Leeds, Hill & Jewett, 1982), ". . . the channel bed throughout the study reach is theoretically stable, even when the flow is near critical."

According to Claude Hunter (1982), the Superintendent of Public Works for the Carson-Truckee Water Conservancy District, the Truckee River through the City of Reno has been slowly aggrading since the main channel was cleaned years ago exposing the footings along the downtown flood walls. This is contrary to the Leeds, Hill & Jewett (1982) report that states that ". . . long term bed degradation adjacent to existing structures is occurring." Inspection of the downtown reach of the river may lead one to believe that the channel has degraded recently due to the slightly exposed footings along the flood walls. Mr. Hunter suggests that the opposite is in fact happening and that the exposed footings remain from the last channel maintenance operation.

Gravel bars currently exist in the center of the channel and in the lee of the bridge piers for some of the old downtown Reno bridges. This tends to support Mr. Hunter's hypothesis of slow aggradation in the downtown area.

Potential sediment-related problems that may result from proposed project channel modifications are:

1. Leeds, Hill & Jewett (1982) have proposed the excavation and removal of approximately 110,000 cubic yards of channel bank and river bar materials along two stretches of the Truckee River. The excavations would be limited to the bed and banks only on one side of the river (see pp 18-20 of their report) for the purpose of increasing channel capacity there. Based on the "Channel Modification Plan" included on page 19 of their report and on Figure

4-3, it appears that a portion of planned excavation will occur along the inside of several bend areas. Our concern is for the likelihood of rapid redeposition of bar materials in those areas. During normal or low-flow years, sufficient material is available from the upper watersheds in the basin to potentially establish new point bars where they once existed. Under average annual hydraulic conditions, it is estimated that point bar buildup along the excavated reach could occur at a rate of approximately 32,000 cubic yards (about 37,000 tons) per year. At this rate the entire excavated amount of bar material could redeposit in a period of less than four years. It is also possible for more than the excavated amount to be deposited during a single 100-year event.

Therefore, channel excavations should be evaluated and designed to minimize the likelihood of redeposition.

2. If the channels are excavated to the point that appreciable amounts of sediment will settle within these areas as a result of reduced channel velocities, it is possible that channel sections immediately downstream could become "sediment starved" and begin to degrade.

3. Removal of large boulders and debris from the main channel should have little impact on the overall river sediment balance and should actually increase the channel's hydraulic efficiency.

4. Removal of Ivan Sack Dam and approximately 30,000 cubic yards of upstream bed material in "an environmentally safe manner" (Leeds, Hill & Jewett, 1982) will be a difficult task. The increased effective bed slope through the excavated area may cause local bed or channel bank scouring until the bed has time to armor itself. This will be especially true if flows through the area approach super critical flow conditions. During critical flow conditions, an unarmored bed can scour as much as ten feet, depending on the magnitude of velocity, duration of the high flow condition, and depth of flow.

   Stability analyses for bed and bank materials should be performed for various flow conditions.

5. It is planned to widen several bridge sections and to adjust the bottom profile through those areas in order to increase the channel capacity. As with item 4 above, analyses should be performed to see if the channel sections will be stable. At some of the bridges (Virginia Street and Center Street), aggradation has been occurring (Hunter, 1982). If bridge sections are widened, it will lead to decreased flow velocities and perhaps increased rates of aggradation.

6. Item 1 above discussed the proposed channel excavations. Associated with these excavations will be the construction of levees. Levees along the outside of bend areas will be protected with riprap, while the inside of the bends will be seeded with grass. In an arid environment such as Reno, the grass banks may not become established without auxiliary irrigation. Such unprotected banks would be unstable. Also, some of these levees are located adjacent to urban housing areas. Would unmowed grass levee banks

present a fire hazard during the summer months? Would the utilization of grass instead of another bank protection method create a larger, long-term maintenance expense?

7. Protective armor materials will no longer cover the bed after excavation is completed. If a large event were to occur shortly after the excavation, it is possible that bank or bed scouring could occur. If this scouring were severe enough, the thalweg could relocate and create a tendency for the river to migrate and impinge on another downstream portion of the bank that may have been previously stable.

8. Leeds, Hill and Jewitt (1982) stated that the channel bed throughout the study reach is theoretically stable, even when the flow is near critical. They also included a summary of HEC-2 printout as part of their Appendix B. There are several cross sections with main channel average velocities in excess of 15 feet per second for the design discharge of 18,500 cfs. According to the USDA, SCS (1977) Technical Release No. 25, "Design of Open Channels," cobbles 8 inches in diameter will move in flows with velocities greater than 13 feet per second. If flows were near critical or located on the outside of a bend, the transport capacity would be even greater.

   It would be advisable to check the bed stability for specific local areas where average channel velocities are expected to exceed 10 feet per second.

9. Along the proposed "U weir overflow area" near the University Farms, an approximate 1,500 foot section of the existing channel will need to be excavated to provide for the alignment and installation of the overflow weir. As currently designed, the channel capacity immediately adjacent to the overflow weir has been approximately doubled. This will allow flows to spill over the weir into University Farms with a minimum amount of turbulence. Unfortunately, the increased channel capacity may lead to long term deposits adjacent to the weir. If not removed each year, these deposits could cause a super elevated water surface over the shoaled area on the outside of the bend that could outflank or overtop a portion of the confinement levee.

   Therefore, we advise increasing the levee freeboard slightly in the area of the weir. Installation of a stout rubble or concrete refusal at the nose section of the weir levee is also important. The back of the weir levee should be riprapped for about 200 to 300 feet downstream from the weir crest to avoid scour induced by turbulent eddying off of the refusal nose section (see Figure 12).

   Also if the channel is excavated down to the current thalweg elevation, the main channel would merely relocate itself on the outside of the bend adjacent to the new levee. A point bar would build in the area of the old channel, and the channel capacity would decrease again. To avoid this it may be better to excavate a high bench area only and leave a main intermediate flow channel where the old main channel is (see Figure 13). The apron along this bench

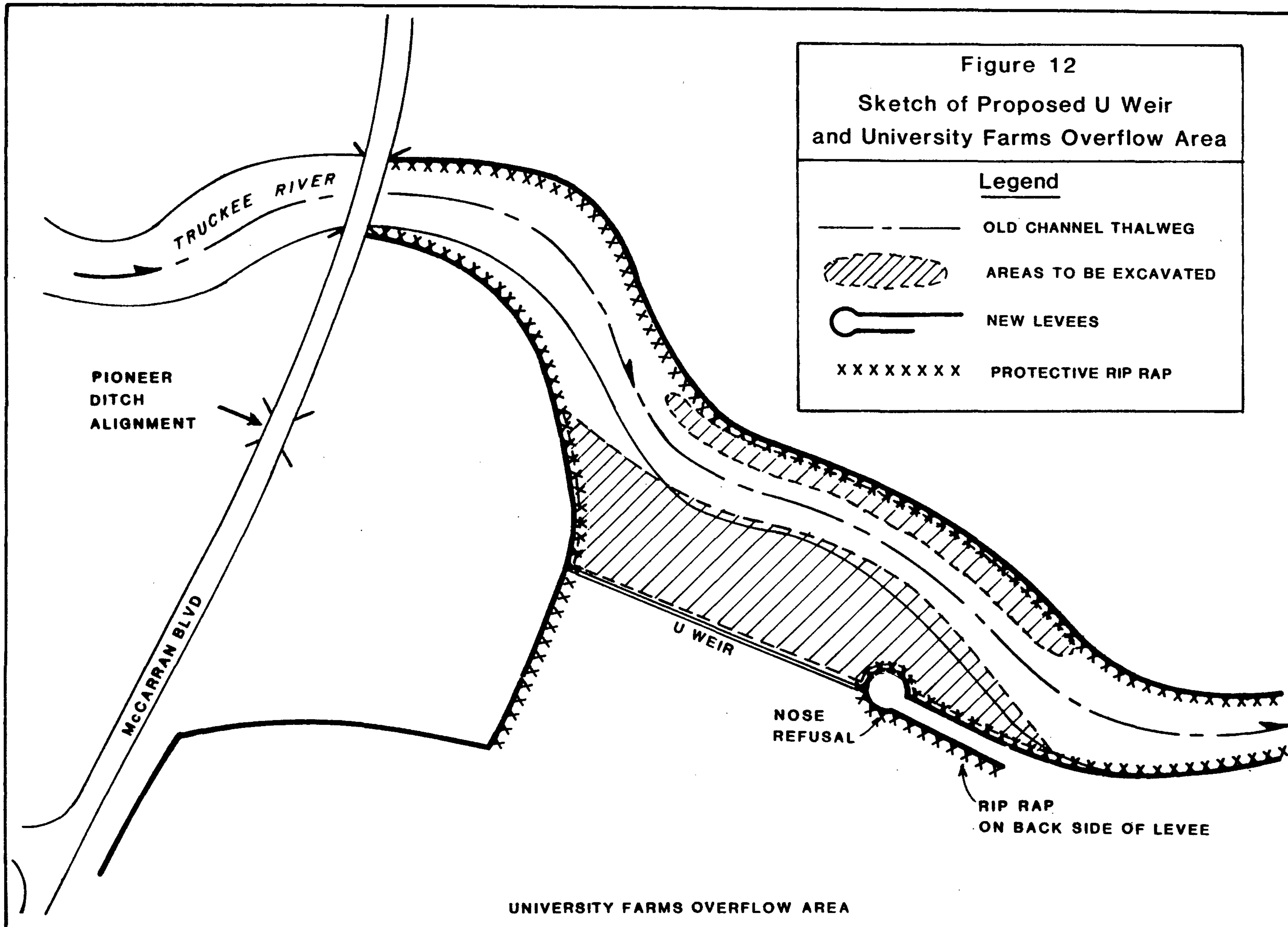


Figure 12
Sketch of Proposed U Weir
and University Farms Overflow Area
Legend
OLD CHANNEL THALWEG
AREAS TO BE EXCAVATED
NEW LEVEES
X X X X X X X X
PROTECTIVE RIP RAP
TRUCKEE RIVER
PIONEER
DITCH
ALIGNMENT
McCARRAN BLVD
U WEIR
NOSE
REFUSAL
RIP RAP
ON BACK SIDE OF LEVEE
UNIVERSITY FARMS OVERFLOW AREA

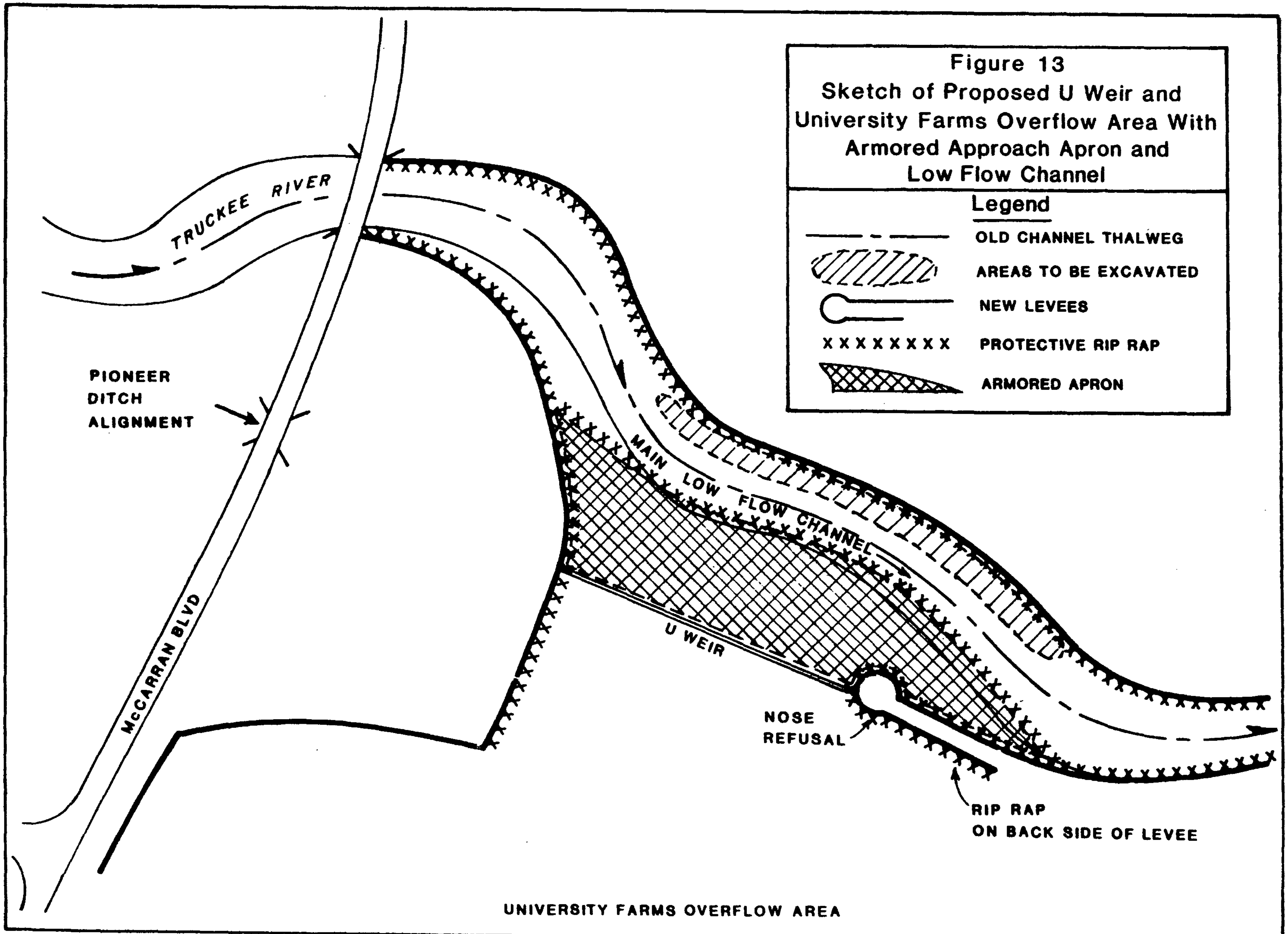


Figure 13
Sketch of Proposed U Weir and University Farms Overflow Area With Armored Approach Apron and Low Flow Channel

area may need to be armored as an approach to the weir. High flows will redirect the main flows at the weir face and probably damage an unprotected approach area. Current project plans limit in-channel excavation to elevations above the 1000 cfs discharge level.

RECOMMENDATIONS FOR FURTHER INVESTIGATION

A careful comparison of existing pre-project hydraulic conditions (including the old bridges and diversions) needs to be made with the improved project channel and bridge configurations. Changing bed slopes and channel velocities as a result of channel modifications will create degradation conditions in some areas and aggradation problems in others. Material removed upstream may be deposited in the lower reaches of the river near the Truckee Meadows as the channel slope decreases (see Figure 1).

Based on currently observed conditions, there appear to be no major sediment related problems in the project area. There are, however, deposition and bank erosion problems along the downstream reaches of the Truckee River below Vista. For the types of materials entering the Truckee River and the quantities estimated herein, it is recommended that critical sections of the proposed channel improvement project be checked to see if net scour or deposition will occur for various ranges of flow conditions.

To do this, sediment behavior should be evaluated separately for pool areas and riffle areas. Under varying flow conditions, materials may continue to travel through riffle areas only to become deposited in pool areas. Above certain critical flows, materials will become mobilized from riffle areas (erosion) and travel through pool areas without depositing. For extreme flows, materials found in the bed in pool areas may become scoured and travel as bed material load through the system. Characterization of this type of flow and sediment transport mechanism should be evaluated carefully with respect to the proposed channel modifications.

As shown in Table 2, the estimated sediment contribution from channel bed and bank erosion is approximately 16 percent of the total load entering the area. Therefore, if in-channel modifications significantly alter local flow regimes, appreciable amounts of sedimentation could be involved. As a result, further investigation of stable channel design is warranted.

Readers should also refer to the previous section on the impacts of the proposed project for additional recommendations and suggestions.

CONCLUSIONS

Based on the data and analyses discussed herein, the following conclusions are made:

1. Water resources-related problems and needs that directly impact the Truckee River and tributaries draining into the Truckee are associated primarily with the serious flood problems that exist through Reno, Sparks, and the Truckee Meadows area.

2. The rates and severity of soil erosion and sediment production throughout the Truckee River Basin are as varied as the topography and climate throughout the area.

3. The Truckee River is a pool and riffle type perennial stream with several man-made bridge crossings and diversion structures located along its course. The channel bed is armored with materials ranging in size from pebbles and cobbles to boulders. The prevalence of large-sized bed materials and armoring decreases from Vista to Pyramid Lake.

4. The section of the Truckee River through downtown Reno is slowly aggrading.

5. The estimated total average annual sediment production from Lake Tahoe to Vista is 102,700 cubic yards per year, or 122,700 tons per year.

6. The basinwide weighted average sediment yield is approximately 0.1 acre feet per square mile per year (includes only those watersheds above Vista).

7. The estimated 100-year sediment production rate from Lake Tahoe to Vista is 1.26×10^6 cubic yards per storm, or 1.51×10^6 tons per storm.

8. Approximately 51,300 cubic yards (61,400 tons) could be deposited in the Truckee River near Truckee Meadows each year during average flow conditions. A single hundred-year event may deposit as much as 630,000 cubic yards per storm or 755,000 tons per storm along the same area.

9. Based on currently observed pre-project conditions, there appear to be no major sediment related problems along the Truckee River from Verdi to Vista.

10. This report has identified, however, several possible project-related sediment problems. Therefore, more detailed evaluation of potential project-related hydraulic and sediment transport problems should be conducted. Investigation of stable channel design and the separate comparative analysis of sediment transport capacities for riffle and pool areas should be performed.

REFERENCES

1. Borland, W.M., (November 1977-a), Memo to Fish and Wildlife Service, Reno, Nevada, Subject: "Sedimentation Problems; Truckee River," Reno, Nevada.

2. Borland, W.M.,(November 1977-b), Memo to the Files, Subject: "Sediment Load of the Truckee River," Reno, Nevada.

3. Brown, John C. and C.M. Skau, (1978), Forested Watersheds of the East Central Sierra Nevada, "Studies of the Quality of Natural Water," University of Nevada, Reno, Nevada.

4. Glancy, P.A., A. S. VanDenburgh, and S.M., Born, (December 1972), "Runoff, Erosion and Solutes in the Lower Truckee River Nevada, During 1969," Water Resources Bulletin, AWRA, Vol. 8, No. 6, pp. 1157 to 1172.

5. Hunter, Claude E., (February 1982), Personal Communication, Reno, Nevada.

6. Leeds, Hill & Jewett, Inc., (1982), Draft Report, "Truckee Meadows Investigation (Reno-Sparks Metropolitan Area) Plan for Channel Modifications, Truckee River," Submitted to U.S. Army Corps of Engineers, Sacramento District, Leeds, Hill & Jewett, Inc., San Francisco, California.

7. Nevada Bureau of Mines and Geology, (1976), Environmental Folio Series, Reno Quadrangle, Mackay School of Mines, University of Nevada, Reno, Nevada.

8. Sacramento District, Corps of Engineers, (July 1973), Operation and Maintenance Manual, "Martis Creek Lake, Truckee River," U.S. Army Engineer District, Sacramento.

9. Sacramento District, Corps of Engineers, (February 1980-a), Hydrology Office Report, "Truckee River California and Nevada, U.S. Army Engineer District, Sacramento.

10. Sacramento District, Corps of Engineers, (July 1980-b), Truckee Meadows Investigation (Reno-Sparks Metropolitan Area) Nevada, "Information Summary on Alternatives for Flood Control and Related Water Resources Problems," U.S. Army Engineer District, Sacramento, California.

11. Sacramento District, Corps of Engineers, (September 1981), "Soils and Geology Study, Truckee Meadows Investigation," U.S. Army Engineer District, Sacramento.

12. Sacramento District, Corps of Engineers, (November 1981), "Memo for File," Subject: Truckee Meadows Investigation, Nevada, U.S. Army Engineer District, Sacramento.

13. Schroer, C.V. and Otto Moosburner, (October 1978), Nevada Streamflow Characteristics, Water Resources-Information Series Report 28, U.S. Geological Survey, Carson City, Nevada.

14. Skau, Clarence M., John C. Brown and John A. Nadolshi, (1982), Draft Copy: "Snowmelt Sediment from Sierra Nevada Headwaters," Paper to be published, journal unknown.

15. SPKCO-O, (1959-1982), "Collection of Bi-annual reports from the Carson-Truckee Water Conservancy District and the Nevada State Engineer's Office," SPK, Sacramento, California.

16. USDA, SEA (December 1978), Agriculture Handbook Number 537, "Predicting Rainfall Erosion Losses," Science and Education Administration, USDA, Washington, D.C.

17. USDA, Agricultural Research Service, (February 1978). Miscellaneous Publication No. 1362, "Sediment Deposition in U.S. Reservoirs, Summary of Data Reported through 1975," USDA Washington, D.C.

18. USDA, SCS, (1971), National Engineering Handbook, Section 3, Chapter 6, "Sedimentation," USDA, Washington, D.C.

19. USDA, SCS, (February 1973), Watershed Investigation Truckee River Subbasin, Appendix III, "Central Lahantan Basin, Truckee River Subbasin, Nevada-California," SCS, Reno, Nevada.

20. USDA, SCS, (Rev. Jan 1975), Technical Release No. 12, "Procedures for Sediment Storage Requirements for Reservoirs," USDA, Washington, D.C.

21. USDA, SCS, (August 1976), "Guides for Erosion and Sediment Control in Nevada," SCS, Reno, Nevada.

22. USDA, SCS, (October 1977), Technical Release No. 25, "Design of Open Channels," USDA-SCS, Engineering Division, Washington, D.C.

23. USDA, SCS, (May 1980), "Stormwater Hydrology and Conservation Treatments in Southwest Reno," prepared for Washoe-Storey Conservation District in Cooperation with the Department of Regional Planning - Washoe Council of Governments, Reno, Nevada.

APPENDIX A

Brief History of the Truckee Meadows Investigation
from SPK, (July 1980)

History of the Investigation

The Truckee Meadows Investigation was authorized on 7 February 1964 by resolution of the Committee on Public Works of the United States Senate.

A public meeting was held in November 1964 to determine desires of local interests, and studies were initiated in Fiscal Year 1965. The tentative flood control plan resulting from these studies consisted of storage on the mainstem of the Truckee River at Verdi, storage and interceptor facilities on Steamboat Creek, and channel improvements in Truckee Meadows. However, when presented with the plan, local interests opposed storage at Verdi because of industrial developments in the proposed reservoir area. Consequently, after further study, an office study concerning Verdi Dam and Reservoir and alternative reservoirs at the Lawton, Hirschdale, Truckee, and Gateway sites was presented to State and local officials. Because of continued lack of support the study was suspended in FY 1970. In May 1974 Washoe County requested the Corps to consider the economic feasibility of an alternative consisting of lowering the Vista reefs and channelizing the Truckee River. In FY 1975, a channel enlargement alternative was studied. Results of this preliminary study, which indicated the channel alternative would be feasible, were furnished to the Washoe County Board of Commissioners in November 1975. In late 1976 Washoe County and the Cities of Reno and Sparks requested that the Corps resume prior studies.

Existing flood control and conservation developments by the Bureau of Reclamation and the Corps of Engineers are summarized in the following paragraphs:

Projects completed by the Bureau of Reclamation in the Truckee River basin are: (a) the Newlands Project, (b) the Truckee River storage project, and (c) the Washoe project. The Newlands project, completed in 1915, consists of the Lake Tahoe outlet control structure, the 290,000 acre-foot Lahontan Reservoir and appurtenant power facilities on the Carson River near Fallon, the Derby Diversion Dam on Truckee River, the Truckee Canal extending from Derby Dam to Lahontan Reservoir, and the facilities for the distribution of irrigation water in the Carson River Basin in the vicinity of Fallon. The Truckee River storage project, completed in 1939, consists of the 40,800 acre-foot Boca Reservoir on the Little Truckee River, together with pertinent distribution facilities of irrigation. Completed in 1970, the portion of the Washoe project above Reno consists of the 30,000 acre-foot Prosser Creek Reservoir on Prosser Creek and the 225,000 acre-foot Stampede Reservoir on Little Truckee River, about 4 miles upstream of the Boca Reservoir. The completed three-reservoir complex of Boca, Stampede, and Prosser Reservoirs provides a total of 60,000 acre-feet of flood control storage and additional flood control protection to Reno, Sparks, and the Truckee Meadows area.

Developments by the Corps of Engineers include a channel modification project authorized by the Flood Control Act of 1954, consisting mainly of widening and deepening the Truckee River channel through Truckee Meadows for about 7.5 miles, extending from the downstream limits of Reno to a point near Vista; minor channel improvements at Lake Tahoe outlet; and minor channel improvements at intermittent points along the river above and below the Meadows area. This work was completed in 1963. Also, the Flood Control Act of 1962 authorized the 20,000 acre-foot Martis Creek Lake, completed in 1972, for flood control and future water supply.

Local interests provided channel improvements along the Truckee River, consisting of riprap and masonry retaining walls for stabilizing both banks through sections of downtown Reno. The work was accomplished about 1930 to 1935 by the Works Progress Administration (WPA) in cooperation with local interests. As a part of the local interests requirements for Martis Creek project, the City of Reno additionally improved the channel to carry a 14,000 cubic feet per second (cfs) flow through Reno. This work was completed in 1972.

APPENDIX B

Summary of Flooding Problems and the Major Flood Control
Works in the Reno, Sparks, Truckee Meadows area
(from SPK, 1980-a and b)

Flood control and related water resources development* - Flood control and conservation developments in the basin are summarized in the following paragraphs:

a. Projects completed by the Bureau of Reclamation in the Truckee River basin are the Newlands project, the Truckee River storage project, and the Washoe project. The Newlands project, completed in 1915, consists of the Lake Tahoe outlet control structure; the 290,000 acre-foot Lahontan Reservoir and appurtenant power facilities on the Carson River near Fallon; the Derby Diversion Dam on Truckee River; the Truckee Canal extending from Derby Dam to Lahontan Reservoir; and the facilities for the distribution of irrigation water in the Carson River basin in the vicinity of Fallon.

The Truckee River storage project, completed in 1939, consists of the 41,100 acre-foot Boca Reservoir on Little Truckee River, together with appurtenant distribution facilities for irrigation. Completed in 1970, the portion of the Washoe project above Reno consists of the 29,800 acre-foot Prosser Creek Reservoir on Prosser Creek and the 226,500 acre-foot Stampede Reservoir on Little Truckee River, about 4 miles upstream from Boca Reservoir. The completed three-reservoir complex of Boca, Stampede, and Prosser Reservoirs provides a total of 50,000 acre-feet of flood control storage and additional flood protection to Reno, Sparks, and the Truckee Meadows area.

b. Developments by the Corps of Engineers include a channel modification project authorized by the Flood Control Act of 1954, consisting mainly of widening and deepening the Truckee River channel through Truckee Meadows for about 7.5 miles, extending from the downstream limits of Reno to a point near Vista; minor channel improvements at Lake Tahoe outlet; and minor channel improvements at intermittent points along the river above and below the Meadows area. This work was completed in 1963. Also, the Flood Control Act of 1962 authorized the 20,400 acre-foot Martis Creek Lake, completed in 1972, for flood control and future water supply.

c. Local interests provide channel improvements along the Truckee River, consisting of riprap and masonry retaining walls for stabilizing both banks through sections of the downtown Reno area. The work was accomplished about 1930 to 1935 by the Works Progress Administration in cooperation with local interests. As a part of the local interest requirements for Martis Creek project, the City of Reno additionally improved the channel to carry a 14,000 cubic feet per second (cfs) flow through Reno. This work was completed in 1972.

d. The Soil Conservation Service has constructed four flood detention reservoirs in the Peavine and East and West wash watersheds north of Reno. These reservoirs contain a total of about 1,200 acre-feet of storage and provide flood protection to urban areas below the reservoirs.

e. There are other small reservoirs and lakes in the basin that contain very small amounts of storage and have no influence on floodflows on the streams of interest in this study.

*from Sacramento District, 1980a.

FLOODING*

Reno, Sparks, and Truckee Meadows have had serious flood problems for many years, and historical accounts show that many damaging floods have occurred from winter rain-snowmelt and summer cloudbursts. Rainfloods, resulting from prolonged heavy rainfall over the drainage area and characterized by high peak flows of moderate duration, can occur in the area any time from November to April. Flooding is more severe when previous rainfall has caused the ground to be saturated, when the ground is frozen and infiltration is minimal, or when warm rain on snow in the higher elevations adds snowmelt to rainflood runoff.

Since about 1960, flood control works, consisting of reservoirs and channel modifications, have reduced the magnitude and frequency of flooding in the area; however, the flood of 1963 inundated a strip one to two blocks wide in Reno along each side of the Truckee River from Idlewild Park on the west to Coney Island Drive on the east. Potential flood damage was greatly reduced by advanced preparation and effective floodfighting. Floods in November 1950, December 1955, and January-February 1963, were similar in magnitude. These severe floods were the most damaging rainfloods because they occurred after residential and business areas of Reno began to spread to the south and southwest. In each flood event, residential, business, and agricultural areas were flooded. Although residential damage was minor, some residents were evacuated from their homes, and some rural residences were isolated by floodwaters and damaged roads. In agricultural areas, irrigation facilities were damaged, livestock was threatened, baled hay and hay stacks were lost, and sand, silt, and other flood debris were deposited on the land. Sections of Steamboat, Lake, and Last Chance Ditches were washed out and streambanks were eroded. The Reno International Airport and about 4,000 acres of agricultural land in Truckee Meadows were also flooded.

The flood plain, shown on Plate 2, consists of the downtown section of Reno, a fringe area on the south and east of the City of Sparks, and the Truckee Meadows. The Meadows begins near the eastern city limits of Reno and extends to the narrow canyon at Vista.

The largest flood of record on the Truckee River in the study area occurred on 23 December 1955 when a peak flow of 20,800 cfs was measured at Reno. That flood caused extensive damage in downtown Reno and in Truckee Meadows. Another large flood occurred on 21 November 1950. During that flood, a maximum flow of 19,900 cfs was recorded at Reno. Damage was particularly heavy in downtown Reno where businesses were flooded and the Rock Boulevard bridge was washed away, and flooding in Truckee Meadows was extensive.

Other large floods on the Truckee River occurred in 1907, 1937, and 1963.

Historical flows and damages caused by the most recent significant floods in the area downstream of Verdi, based on prices and conditions at the time of the flood, are shown in the following tabulation.

*from Sacramento District, 1980b.

Floods of Record
(Reno Gage)

Date of Flood	Peak Flow (cfs)	Estimated Damage ($)
Nov 1950	19,900	$2,470,000
May 1952	7,950	230,000
Dec 1955	20,800	1,680,000
Feb 1963	18,400	1,680,000
Dec 1964	11,300	1,320,000
Jan 1980	8,650	Not determined

The Truckee Meadows, once predominantly rural-agricultural, is changing to an urban-industrial complex. The current estimate of damageable property in the Truckee Meadows Standard Project Flood Plain, excluding the value of lands, roads, bridges, utilities, and railroads, is $1,244,000,000. Damages to existing development in the Truckee Meadows (Reno-Sparks metropolitan area) would amount to approximately $170 million with a recurrence of the December 1955 flood and $145 million with the February 1963 flood, assuming similar hydrologic and climatic conditions of the prior events.

APPENDIX C

Photographs from the Field Reconnaissance Trip

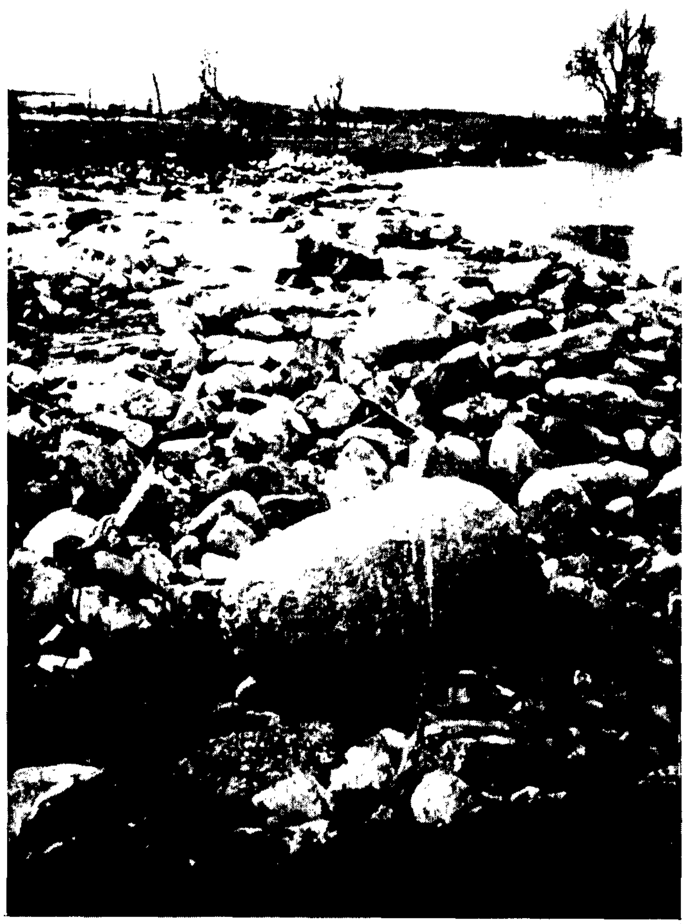
9-11 February 1982

A Sharp Bend Along the Truckee River
Near Verdi along Old Highway 40

(Notice coarse bed materals)

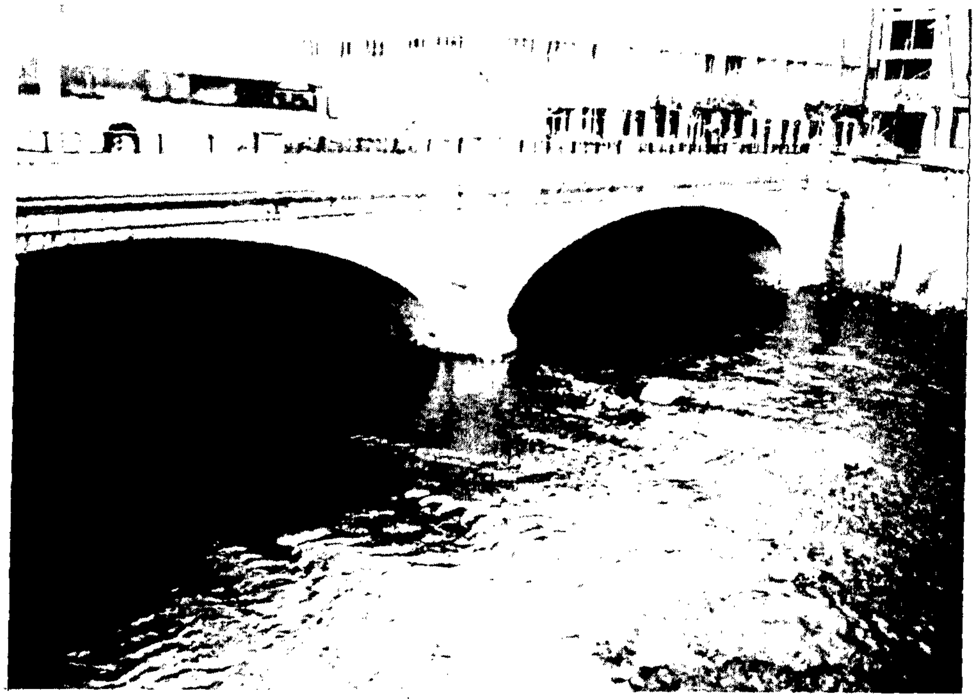
Truckee River Near Lawton
Bed is Armored with Large Cobbles

Boulder Diversion Structure near Rock Boulevard Park

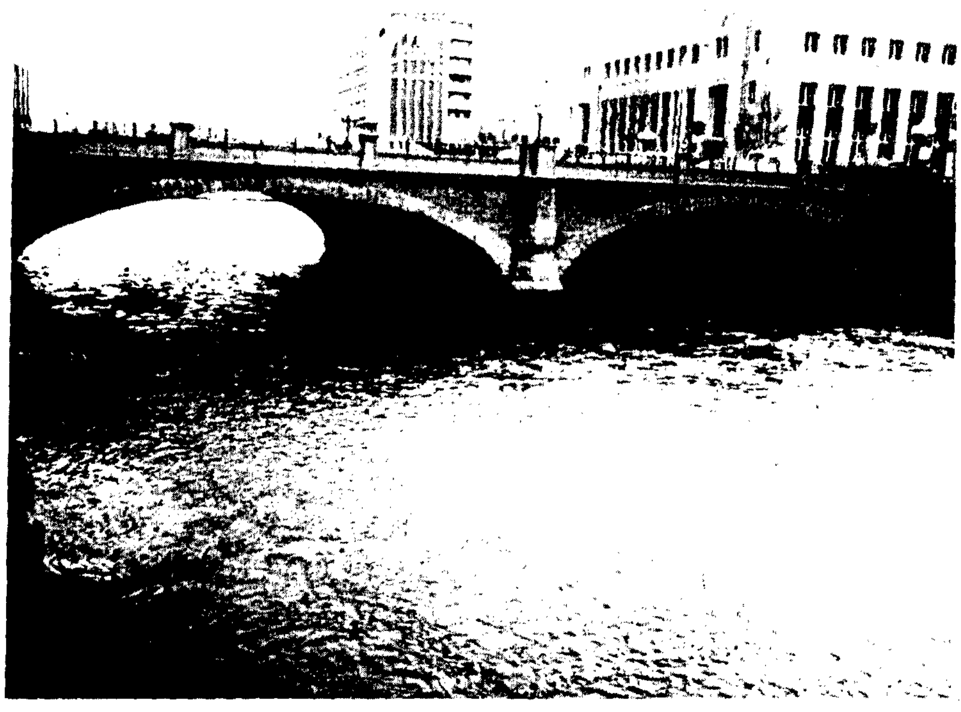


A Closer Look at the Rock Park Diversion Dam

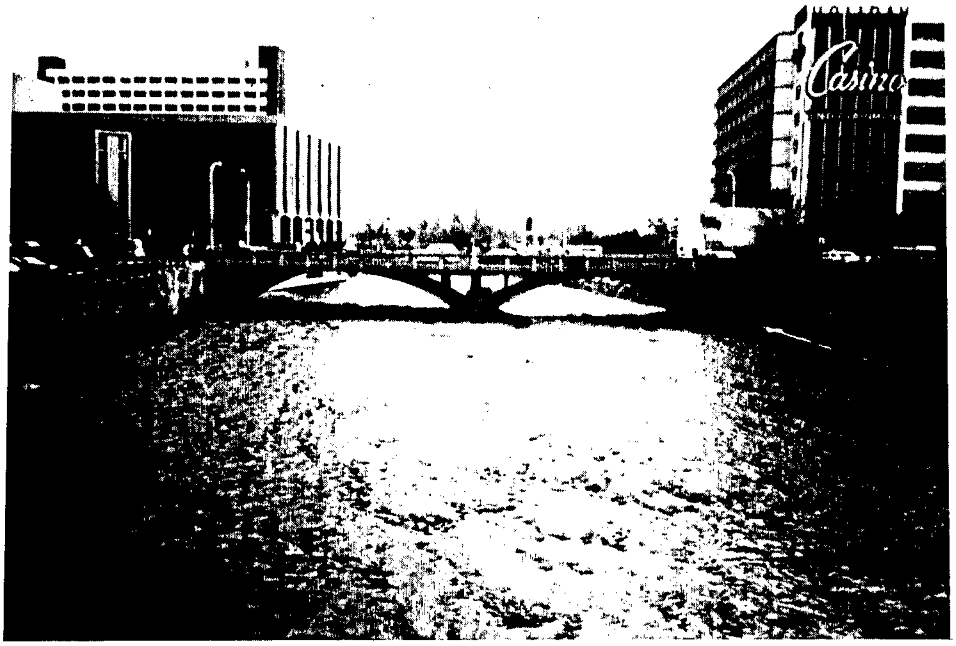
(Notice that some of the large materials in the center of the dam have been dislodged downstream during a past high flow)



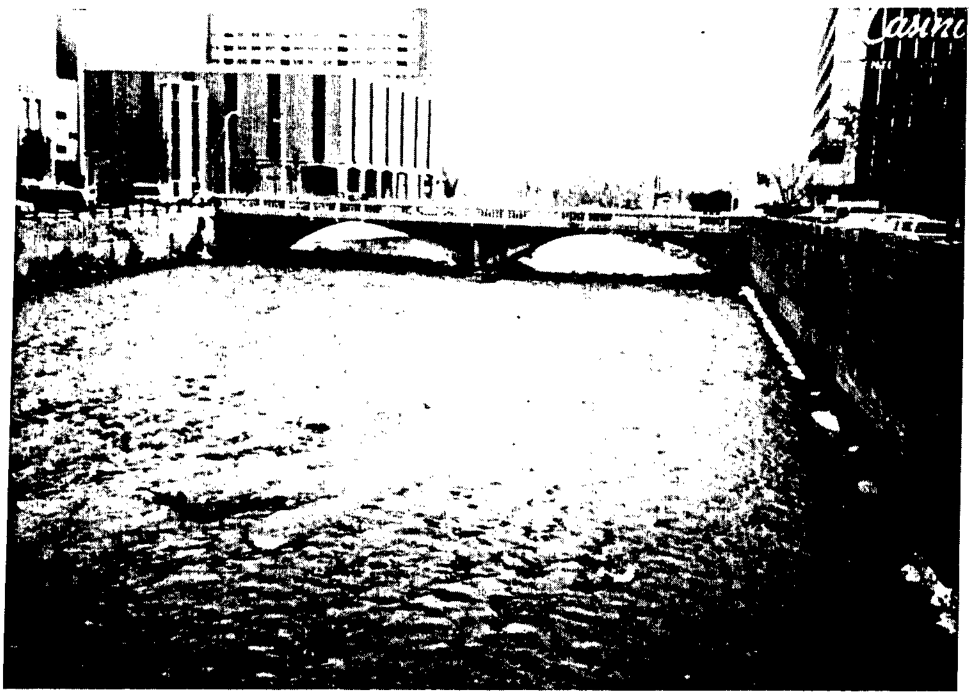
Virginia Street Bridge, Reno



Virginia Street Bridge, Reno



View of Center Street Bridge, Reno
(Notice exposed floodwall footing)



View of Center Street Bridge, Reno
(Notice exposed footings and center channel shoaling)

Debris Buildup at Bridge Crossing
(Notice fine material deposits behind debris dam)

Looking Upstream at I-395 Bridge
(Notice large boulder in center of channel)

Section F

Basis of Design

SECTION F
BASIS OF DESIGN
TRUCKEE MEADOWS INVESTIGATION

TABLE OF CONTENTS

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LIST OF PLATES

TRUCKEE MEADOWS INVESTIGATION
BASIS OF DESIGN

CHAPTER I - INTRODUCTION

GENERAL

1. The metropolitan area of Reno extends along both banks of the Truckee River from about Mayberry Bridge to the eastern city boundary, a distance of about 7 miles. Sparks adjoins Reno and is located northeasterly from Reno. Truckee Meadows, which is actually the remnant of a much larger meadow area, lies easterly and southeasterly of the Reno-Sparks metropolitan complex. The Meadows is a low-lying area traversed for about 5 miles by the river and is drained by Steamboat Creek.

2. The study area comprises the flood plains along the Truckee River from the western city limits of Reno downstream to the Vista stream gage located near the most easterly city limits of Sparks; Steamboat Creek from its confluence with the Truckee River upstream through the Steamboat Creek marsh area to the Bella Vista Ranch Road, and Boynton Slough from its confluence with Steamboat Creek upstream to McCarran Boulevard.

3. Available records of streamflow date back to 1895 when the U.S. Geological Survey (USGS) established a gaging station at the outlet of Lake Tahoe. Additional stations were installed at Farad and Vista in 1899 and at Reno in 1906. Streamflow measurements on the major upstream tributaries have been made intermittently since the early 1900's and continuously since the late 1950's and early 1960's. Except for Steamboat, Hunter, and Peavine Creeks, for which records date from the early 1960's, no streamflow records have been made on the tributary streams joining the Truckee River in the study area.

4. The Truckee River has been studied by the Corps of Engineers in connection with channel improvement work completed in 1960, in connection with the authorization and preconstruction planning of the Martis Creek Project, and in connection with preparing flood control operation regulations for Boca, Stampede, and Prosser Creek Reservoirs. Flood damage surveys of the Reno-Sparks-Truckee Meadows area were conducted by the Corps of Engineers after the 1950, 1955, and 1963 floods. A Stage 2 Report was completed in December 1979.

HISTORY

5. The Reno-Sparks area has an interesting and colorful history. Trappers and traders were the first white men to visit the area, and the ill-fated Donner Party, one of the first emigrant trains to pass through, traveled up the Truckee River in late 1846. The fate of the Donner Party so frightened later emigrants that for over a decade groups wintered near the lush Truckee Meadows rather than attempt a late crossing of the Sierra Nevada.

6. After discovery of the Comstock lode in 1859, the Nevada Territorial Legislature chartered toll roads and bridges to encourage road building. Such a charter was granted to C. W. Fuller of Susanville in 1859. He settled in what was to become downtown Reno, and built a crude hotel and a bridge at about the same location as the present-day Virginia Street Bridge. Within a short time, the area became known as "Fuller's Crossing." In 1863, Fuller sold his bridge to C. M. Lake who claimed about 1/3 of a section extending across the river at the bridge site. By 1864, the Central Pacific Railroad completed the western section of the transcontinental line to Dutch Flat, California, and a road from Dutch Flat to Virginia City by way of Donner Pass

and [now] "Lake's Crossing." This road took most of the traffic from the Placerville-Carson City route, and Lake's Crossing became the nucleus of a tiny settlement. The railroad was completed to Lake's Crossing on 9 May 1868 and the Central Pacific acquired 80 acres from Lake on the condition that a station be located thereon. A townsite was laid out, lots were sold, and the present City of Reno was established. It was named in honor of General Jesse Lee Reno, a Union officer in the Civil War. In 1871 the county seat was moved to Reno from Washoe City, 15 miles to south. Reno's prosperity as a trading center gained new impetus when the Virginia and Truckee Railroad was completed in 1872, connecting Virgina City with Reno and the transcontinental rail service provided by the Central Pacific Railroad.

7. Reno's early growth was largely dependent upon the railroad, whereas the origin of Sparks was entirely due to the railroad. Until about 1900, the railroad's division shops were located at Wadsworth, about 35 miles to the east of Reno. Since a suitable site could not be found in the city, a site on the Thomas Martin Ranch 4 miles to the east was selected. New shops were built during 1902-1903 and, on 4 July 1904, the railroad moved homes, shrubbery, fruit trees, pets, household goods, and the workers and their families to new homesites selected by lottery at the new location. The new community was first called Harriman in honor of the President of the Union Pacific Railroad, but its name was changed to Sparks in honor of John Sparks, the Governor of Nevada at the time. Sparks was incorporated in 1905.

CHAPTER II - GEOLOGY

SCOPE

1. This section summarizes geological and soils data obtained from a literature search and field reconnaissance in the Reno area. The section includes an assessment of local geological and foundation conditions along the Truckee River and adjacent areas.

REGIONAL GEOLOGY

2. Reno is located on the western edge of the Great Basin in an area that is transitional between the Basin and Range and the Sierra Nevada physiographic provinces. The Truckee River, in Reno and Sparks, flows eastward through the Truckee Valley and the northern portion of Truckee Meadows. Truckee Meadows is a structural basin bounded on the west by the Carson Range, on the east by the Virginia Range, on the south by Steamboat Hills, and on the north by the Peavine Mountain block (Bingler, 1975). The oldest rocks in the area are the structurally complex Mesozoic metavolcanic and metasedimentary rocks of the Peavine sequence that were intruded by granitic plutons (Nevada Bureau of Mines and Geology - NBMG - Reno Folio, Environmental Series, 1976). These older rocks are overlain by a thick sequence of Tertiary volcanic and epiclastic rocks consisting of lava flows, breccias, and tuffs. Large areas of the volcanics are hydrothermally altered. Miocene to late Pliocene age fluviatile and lacustrine sediments were the initial deposits to accumulate in the downwarped Reno Basin. These deposits, consisting of conglomerate, siltstone, sandstone, and a diatomite are exposed along the margins of Truckee Meadows. According to Bingler (1975) three major categories of Quaternary

deposits in Truckee Meadows represent a long-established pattern of basin sedimentation. These consist of: (1) Holocene to Recent Truckee River gravel and Pleistocene glacial outwash deposits, (2) Quaternary to Holocene complex alluvial fan deposits around the margins of Truckee Meadows, and (3) Holocene to Recent fine-grained flood plain and lake deposits throughout the central and eastern part of Truckee Meadows.

3. The geologic structure of the area was produced by faulting and warping that began by at least Miocene time and continued into Holocene time. Quaternary faults are common and widespread in the area of the Mount Rose fan complex, northwest of Steamboat Hills, and northward through Reno. Nearly all are normal faults that display Pleistocene movement, but some cut Holocene deposits. Displacement of these faults ranges from a few feet up to about 50 feet. The higher scarps are present along the west edge of Virginia Lake, southward along the basin margin at Thomas and Whites Creeks, and along the northwest side of Steamboat Hills (Bingler, 1975). Another prominent set of faults trends N. 20° to 45° E. and is concentrated in a 2-mile-wide zone located immediately northwest of the Truckee River in west Reno.

AREAL GEOLOGY

4. The Truckee River follows a winding eastward course through the Truckee River valley west of Reno and into Truckee Meadows east of Reno and Sparks. The distribution of geologic materials within the project area is shown on Plate 1, Areal Geology. The materials are described in the NBMG Reno Folio, and in Bingler (1975). The entire project area is underlain by late Pleistocene Donner Lake and Tahoe glacial outwash deposits. The outwash has been reworked by the Truckee River and deposited along its modern flood plain

overlying Tahoe outwash. Near the western end of the project area the Donner Lake outwash consists of a veneer over bedrock and is about 30 feet or less in thickness. It thickens eastward to about 330 feet or more under Reno. Similarly, the Tahoe outwash forms an extensive alluvial wedge, thickening eastward from about 300 feet in west Reno to over 1,000 feet beneath Sparks. Both the Tahoe and Donner Lake deposits contain large boulders known to be at least 16 feet in diameter. East of Reno International Airport the Tahoe outwash is overlain by varying thicknesses of Holocene flood plain and lacustrine or swamp deposits. Adjacent areas are covered by alluvial fan and sediment deposits. The flood plain materials consist primarily of silt, clayey silt, and silty sand containing scattered thin lenses of peat, 1 to 2 feet thick, and clay-rich interbeds. The materials vary in thickness from a feather-edge against Tahoe outwash to as much as 27 feet in northeastern Truckee Meadows.

5. The Soil and the Physical Properties Map in the NBMG Reno Folio indicates there are areas of poorly drained soils scattered along the Truckee River through Reno and Truckee Meadows. The mainstream and glacial outwash deposits generally have medium to high permeability, low compressibility, low shrink-swell potential, excellent drainage, good bearing capacity, low plasticity, and low relief. The flood plain and lake deposits have discontinuous layering, impervious to low permeability, moderate to high compressibility, low to medium shrink-swell potential, impervious to fair drainage, fair to poor bearing capacity, low to high plasticity, susceptibility to liquefaction, and low relief.

6. The Hydrologic Map in the NBMG Reno Folio shows the depth to the water table adjacent to the Truckee River through Reno and Sparks to be about 20 feet, although much of the area is shown as a fairly continuous, probable ground-water discharge area, the intensity of which varies seasonally. Water depths are expected, according to drilling data from foundation reports on construction throughout Reno, to vary considerably from about 4.5 to 20 feet for most of the western project area and from about 6 to 12 feet in Truckee Meadows.

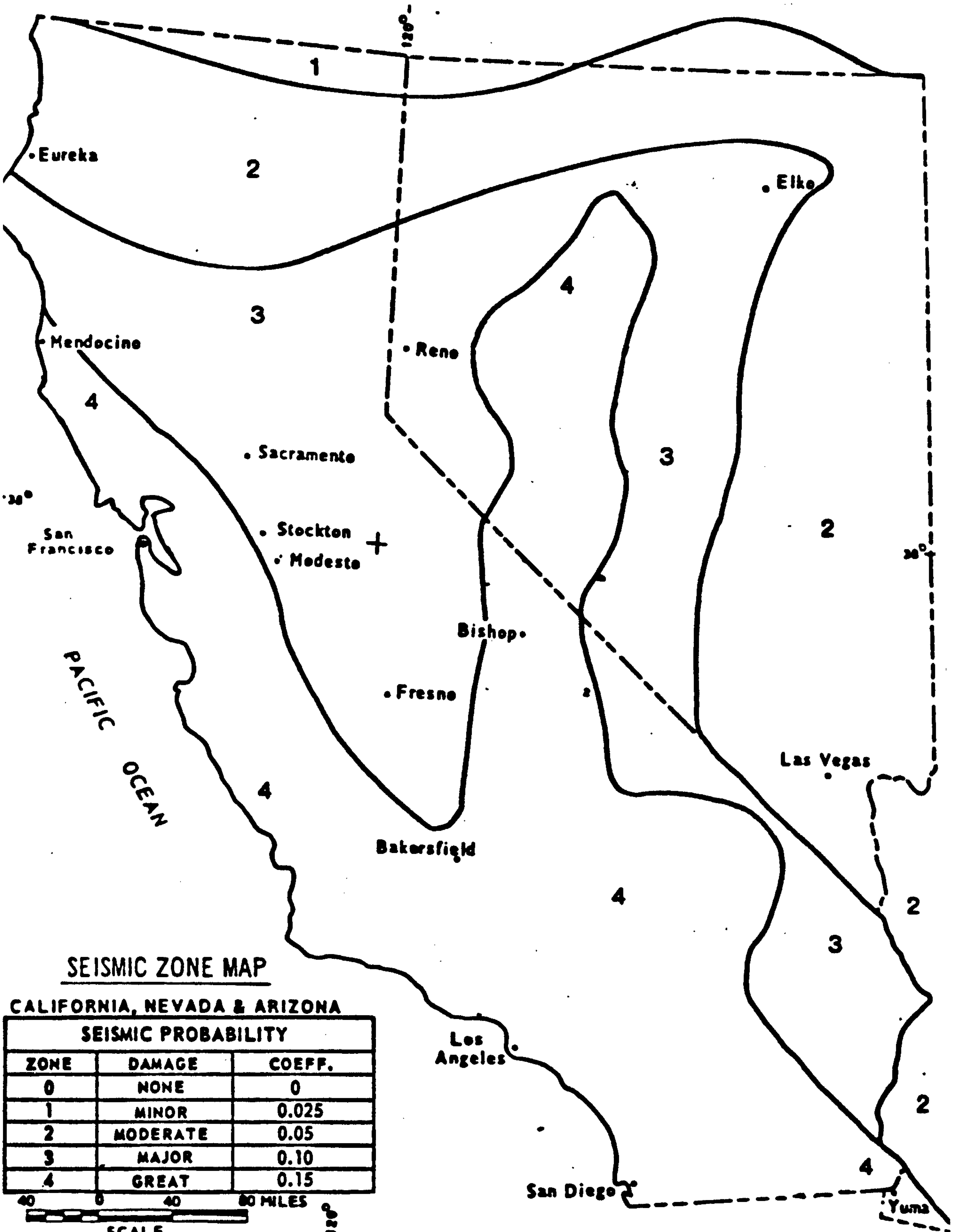
7. The distribution and relative age of fault traces in the Reno area are shown on the Earthquake Hazards Map of the NBMG Reno Folio. A prominent set of northeast-trending faults of early to middle Quaternary Age occur in northwest Reno and those shown in central Reno are post-Illinoian. One northeast-trending fault of post-Wisconsin Age crosses the Truckee River north of the Reno International Airport. About 1-mile northeast of that fault, there is a short, more northerly trending fault that may cut Holocene deposits believed to be laterally equivalent to other deposits dated at 2130 years old. The east margin of Truckee Meadows is bounded by a fault of late Pleistocene to possibly Holocene Age. Also, an obscured fault, with indications of fairly recent activity, may lie due north of the sewage facility through the center of Sections 11 and 2 (John Shilling, NBMG, oral communication). Areas underlain by glacial outwash and mainstream deposits of the Truckee River are believed to be potentially unstable and subject to pronounced slumps and ground disturbances along steep cuts or embankments during a major seismic event. Areas underlain by Quaternary flood plain and lake deposits are subject to liquefaction, severe ground motion, and surface dislocation, especially in areas of ground-water discharge or where the soils are saturated.

REGIONAL SEISMICITY AND FAULTING

8. Extreme western Nevada is in Seismic Zone 3, which has a moderate-to-high earthquake hazard (Figure 1). Seismicity of the Reno area is average for the Western Basin and Range province, although, about 40 miles east of Reno is the 118° Meridian Zone that is considered to be historically the most active zone in the United States. It is in Seismic Zone 4. In historic time, the most severe earthquakes in the area include those of magnitudes 6.0 and 6.4 just south of Reno in 1914, magnitude 6 earthquakes near Virginia City in 1869 and near Verdi in 1948, and a magnitude 5.7 earthquake north of Truckee in 1966. Historic earthquakes of unknown magnitude occurred on the Fort Sage fault near Herlong, California in 1850 and on the Mohawk Valley Fault northwest of Sierraville, California in 1875. Major historic earthquakes in western Nevada in the 118° Meridian Zone are tabulated below:

Date	Location	Magnitude	Distance from Reno (Miles)
1845	Stillwater Area	Unknown but strong	50
1872	Owens Valley	8.3	170
1915	Pleasant Valley	7.8	110
1932	Cedar Mountains	7.3	105
1954	Fallon-Stillwater Area	6.6	70
1954	Fallon-Stillwater Area	6.8	70

9. From 1940 to 1970, approximately 70 earthquakes with magnitude 4 or greater occurred within 100 km (62 miles) of Reno. The Earthquake Epicenter Map (Figure 2) shows the magnitudes and relative density of epicenter locations around Reno and eastward. The two 1914 earthquakes noted above are not plotted on the epicenter map because of uncertain location data (Trexler, oral communication). The first had an intensity of VII (Modified Mercalli



SEISMIC PROBABILITY		
ZONE	DAMAGE	COEFF.
0	NONE	0
1	MINOR	0.025
2	MODERATE	0.05
3	MAJOR	0.10
4	GREAT	0.15

TRUCKEE MEADOWS INVESTIGATION
(RENO-SPARKS METROPOLITAN AREA)
NEVADA

SEISMIC ZONE
MAP

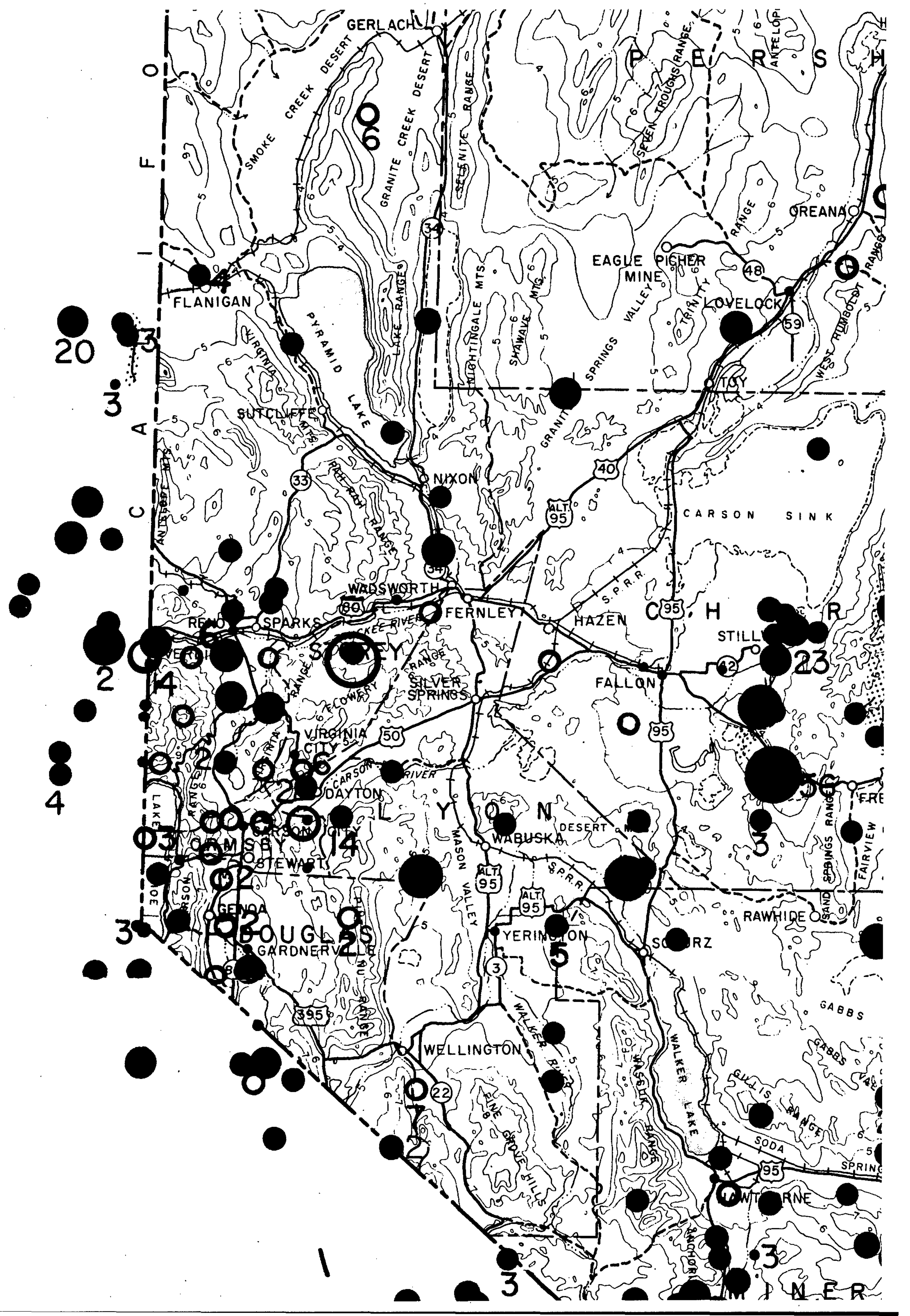
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

FIGURE 1

Scale) in the Truckee Meadows area. It cracked buildings and had two distinct shocks lasting from 6 to 30 seconds. The second had an intensity of VIII in Reno. It last 10 seconds and toppled chimneys in the area.

10. Two major fault systems are responsible for most of the seismic activities in western Nevada. The Sierra Nevada Frontal System is an irregular zone of major and secondary faults extending from the Garlock fault northward along the east side of the Sierra Nevada for more than 400 miles. A second major zone, that may be related to the frontal system is the 118° Meridian Zone that trends southwest from Winnemucca to at least Owens Valley. Reno lies between these two major zones. According to the Earthquake Hazards Map in the NBMG Reno Folio, faults shown on the geologic map (Figure 1), may be splay faults from the frontal fault system. Most of them are normal faults that dip to the northwest, although some dip northeast. Many of these faults have been stratigraphically age dated (Bingler, 1975). They displace Pleistocene alluvial fan deposits and pediment gravels, and a few cut Holocene deposits. Cordova (1969) has found three to five separate movements on faults just south of Reno on the Mount Rose fan complex, during Holocene time (the last 11,000 years). According to Bingler (oral communication), a zone of recent micro-seismic activity is centered about 9 miles south of the Truckee River in the vicinity of Steamboat Hot Springs. For lack of evidence to the contrary, the faults cutting through the area must be considered to be capable faults.

11. Earthquakes with magnitudes of 7.25 to 7.6 could be centered in the area immediately south of Reno (Ryall and Douglas, 1975; D. B. Slemmons, personal communication). Slemmons also believes that the northeast trending faults in the area are capable of generating 6.0 to 6.5 magnitude earthquakes. Discussions


GERLACH
SMOKE CREEK DESERT
GRANITE CREEK DESERT
SELENITE RANGE
SEVEN TROUGHS RANGE
P E R S H
OREANA
EAGLE PICHER MINE
LOVELOCK
FLANIGAN
PYRAMID LAKE
LAKE RANGE
NIGHTINGALE MTS.
SHAWAVE MTS.
SPRINGS VALLEY
WEST HUMBOLDT RANGE
TOY
SUTCLIFFE
NIXON
CARSON SINK
WADSWORTH
FERNLEY
HAZEN
RENO
SPARKS
STILL
SILVER SPRINGS
FALLON
VIRGINIA CITY
CARSON RIVER
DAYTON
L Y O N
WABUSKA
DESERT
CARSON CITY
STEWART
MASON VALLEY
RAWHIDE
GENOA
DOUGLAS
GARDNERVILLE
YERINGTON
SCHURZ
GABBS
WELLINGTON
WALKER RIVER
WALKER LAKE
PINE GROVE HILLS
SODA SPRINGS
HAWTHORNE
FAIRVIEW
SAND SPRINGS RANGE
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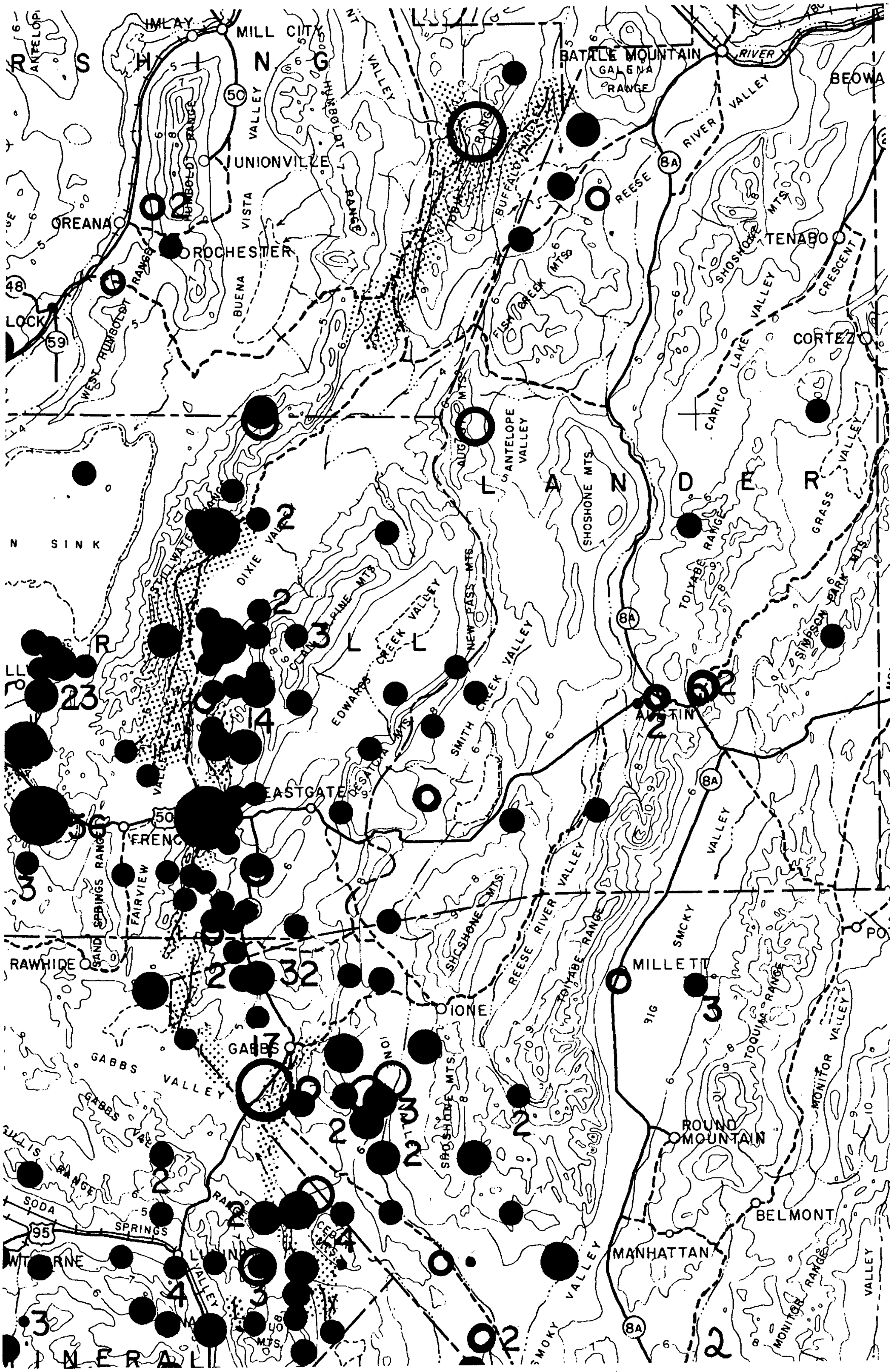

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EARTHQUAKE EPICENTER MAP, RENO, NEVADA AREA

COMPILATION: D. B. SLEMMONS, J. I. GIMLETT, A. E. JONES, R. GREENSFELDER, J. KOENIG

MAGNITUDE SCALE

1854 - 1931		1932 - 1960
○	7.0 +	●
○	6.0 - 6.9	●
○	5.0 - 5.9	●
○	4.0 - 4.9	●
	Low Magnitude, felt	●

DECEMBER 1964

NOTE:
Figures adjacent to circles indicate the number of events that occurred at those locations.

Zones of historic surface faulting; faults indicated by solid lines.

Nevada Bureau of Mines
University of Nevada
Reno, Nevada

Base from NBM Map 17

Scale 1:1,000,000

0 10 20 30 40 50 100 Miles

0 10 20 30 40 50 100 Kilometers

Contour Interval 1000 Feet

FIGURE 2

of recurrence curves, bedrock accelerations, and return periods in the NBMG Reno Folio gives the following data for an average site in western Nevada, including the Reno area. Small accelerations (0.1g or more) have return periods of about 13 years when caused by earthquakes with magnitudes of 5 or greater; 33 years when caused by magnitude 6 or greater (more distant) earthquakes; and 140 years when caused by magnitude 7 or greater (distant) earthquakes. Accelerations of 0.3g or more are caused by earthquakes large enough (magnitude 6 or greater) to have more than 10 seconds duration and have return periods of about 200 years. Accelerations of 0.5g or more are caused by nearby great earthquakes (magnitude 7 or greater) and would be expected only once in 2,000 years.

CHAPTER III - DESIGN DATA BASE

GENERAL

1. The data base developed for the basis of design is discussed in the following paragraphs. Data was compiled from studies conducted by the USCOE, Sacramento District. Previous data was updated to reflect changes such as streambank alterations, revised hydrology, revised topography, urbanization, and industrialization. Some of the data was supplied by the Public Works Departments of Reno and Sparks (mostly revised bridge data and utility locations) and the United States Department of Housing and Urban Development (HUD), Flood Insurance Administration (FIA) for stream cross-sectioning and mapping.

SURVEYS

2. Topography used for the investigation consists of photogrametric mapping completed by a private engineering firm for the FIA. The maps, in manuscript form, were compiled from 1980 aerial photographs at a scale of one inch equals 200 feet and two foot contour intervals. Cross-section data consists of digitized sections supplied by the FIA and additional sections scaled from the 1980 topography maps.

EXPLORATIONS

3. Soil exploration data for the Truckee River was obtained from private engineering firms and governmental agencies (see reference 4). Additional explorations were obtained by COE in the University Farms Overflow area, the

Steamboat Marsh area, and along the north bank of the Truckee River between South Rock Boulevard and the Vista stream gaging station (see reference 5). Selected soil information is shown on Plates I and II.

SOILS TESTING

4. Previous laboratory soils testing conducted on the exploration sites listed in reference 4 are unavailable except in an average range of values for a given area. Comprehensive laboratory testing was conducted on selected soil samples from the exploration sites drilled in 1982. The testing program included sieve analyses for determination of grain size and distribution, one-dimensional consolidation tests, Atterberg limits, natural water content, in situ dry density, organic content, and specific gravity determinations. Consolidated drained direct shear tests and unconsolidated undrained and consolidated undrained (with pore pressure measurements) triaxial tests were also performed to determine the strength of some of the soils. Soil classification for selected samples are shown on Plate I.

HYDROLOGY

5. An extensive hydrology report was completed by USCOE, Sacramento District in February 1980 (reference 1). The following paragraphs summarize some of the more important hydrologic details relating to this study. Precipitation in the headwater areas of the Truckee River Basin usually is associated with storms which occur during the months of November through April inclusive. The storms originate over the Pacific Ocean and move eastward to and over the Sierra Nevada range. Some of these storms pass through the Donner Pass gap causing heavy rainfall on the lower slopes of the Sierra Nevada within the

Truckee River Basin and on the Mount Rose ridge northeast of Lake Tahoe. The storms last from 1 to 4 days. Localized cloudburst storms occur frequently during summer from July through August. Cloudburst storms usually result when moist warm air reaches the area from the Gulf of California.

6. The Truckee River and its tributaries, with the exception of the Truckee Meadows area, are mountainous streams confined to narrow canyons, consequently channel storage is relatively small and peak flow attenuation is minimal. Accordingly, flood routings for the Truckee River Basin are based on the Muskingum Method supplemented by Modified Puls routing where storage influences downstream flows (as in the Truckee Meadows area).

7. Hydrology was developed for present land-use conditions (1980) and estimated future land-use conditions (1990). In the Reno area land-use changes may have some impact on runoff. In other portions of the basin land-uses are not expected to change significantly and therefore will have no impact on runoff. Land use projections are based on those prepared by the Washoe County Regional Planning Commission (1978 Preliminary General Plan).

EXISTING STORM DRAINAGE SYSTEMS

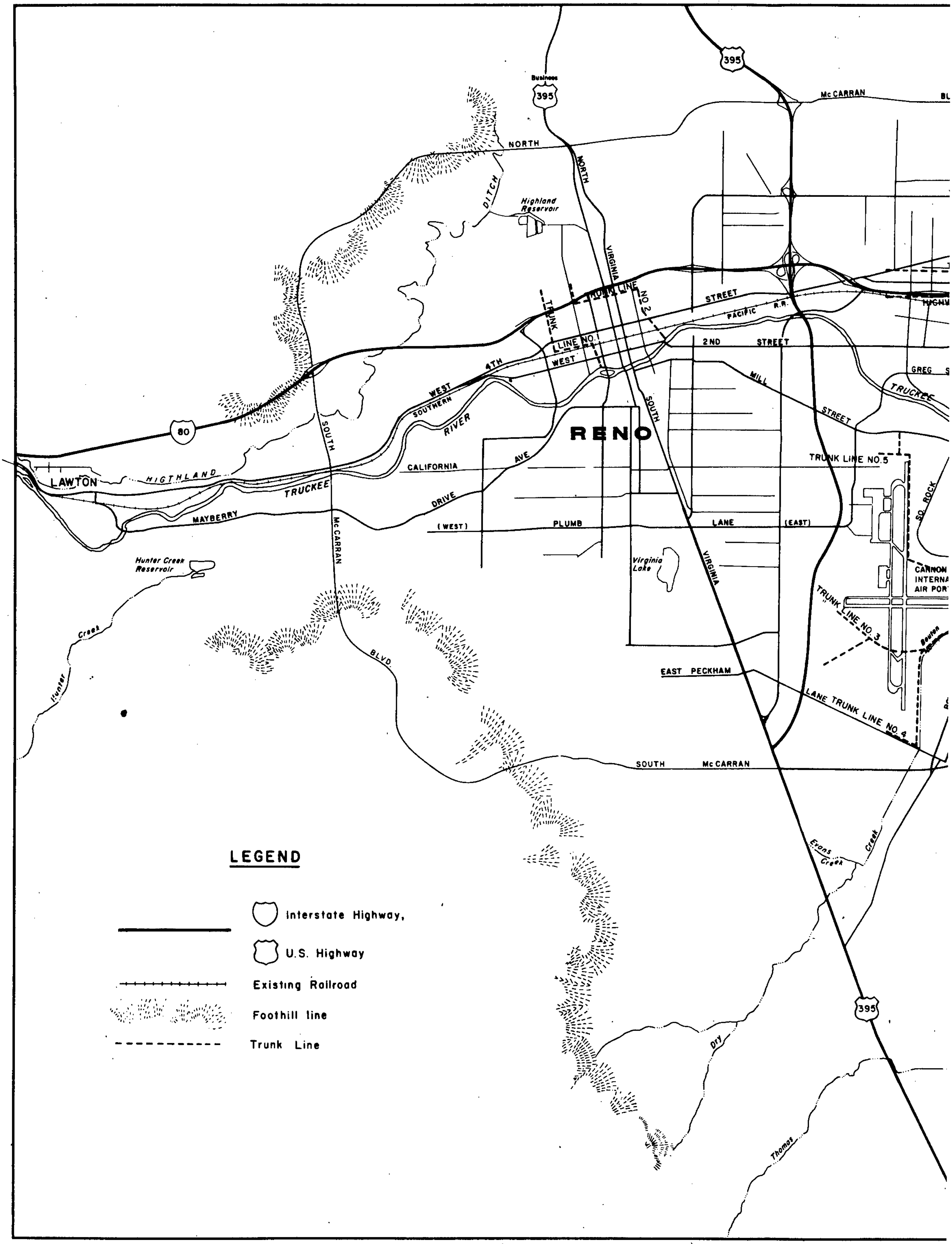
8. The following paragraphs contain a brief description of the storm drainage systems within the Cities of Reno and Sparks. The information, including drainage system maps of each city, was obtained from the respective City Engineering Departments. Figure 3 shows a composite map of the storm drain systems.

RENO

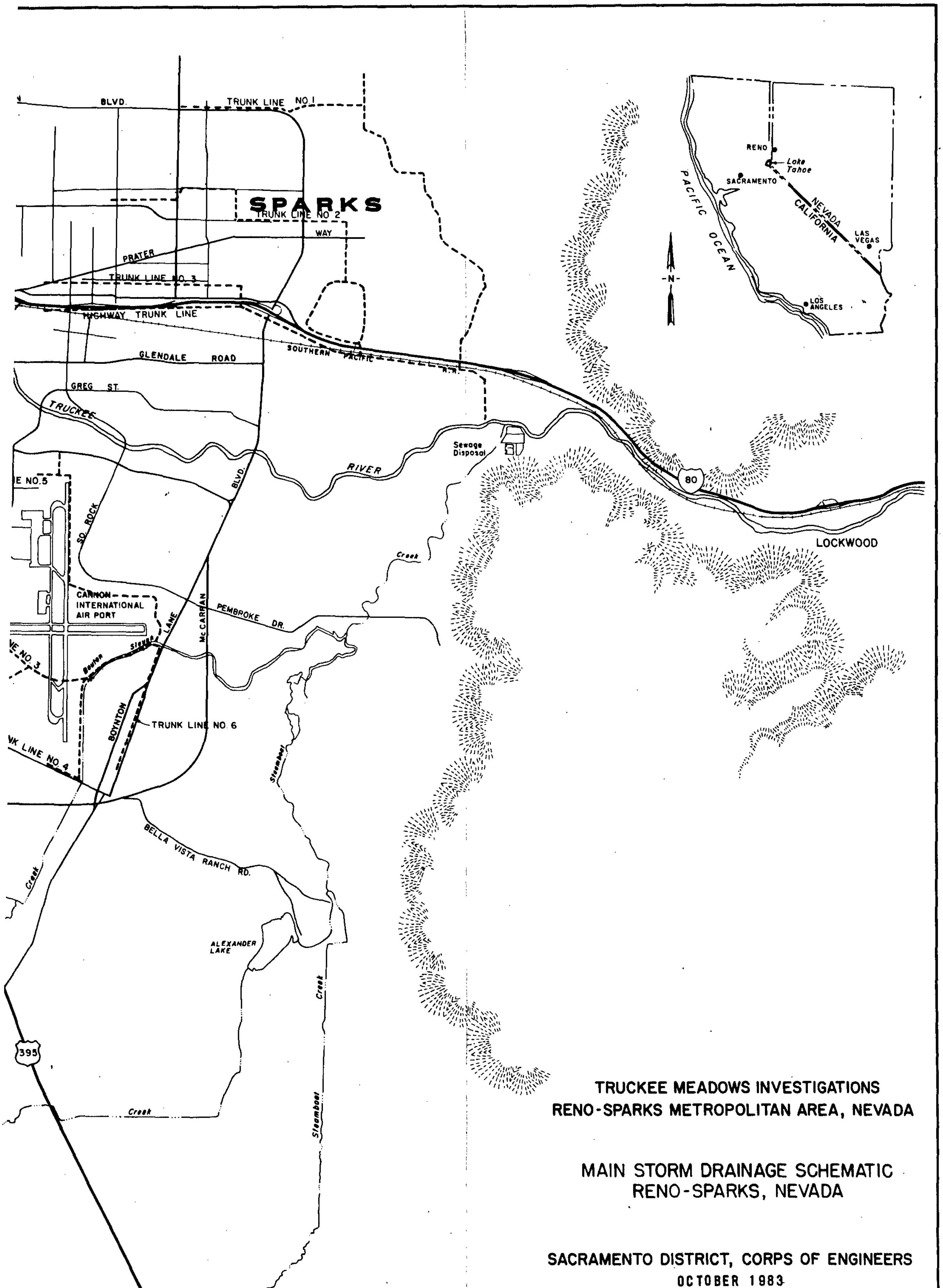
9. The storm drain system in Reno consists of two collector lines north of the Truckee River and four collector lines in the south part of Reno. One main trunk line collects storm runoff in the North-West section of Reno and discharges into the Truckee River near Arlington Avenue. The second trunk line in north Reno drains an area east of Vine Street and north of West Sixth Street. This flow is routed to an outfall on the Truckee River near the Second Street Bridge. The storm drain collector system in South Reno consists of four separate systems, each system discharges into Boynton Slough. One trunk line collects storm flows from an area west of the North-South runway of Cannon International Airport and conveys the flow under the runway to an outfall on Boynton Slough. Another open ditch trunk line collects storm water in the Southwest portion of the city routes the flow around the South end of the same runway and terminates at Boynton Slough. The third trunk line drains into Boynton Slough adjacent to the Boynton Lane Bridge. This trunk line collects storm flows in an area east of the MGM Grand Hotel complex and south of the river, and conveys the flow around the north end of the North-South runway. Additional storm flow is collected east of the runway and combined with the North-West flow and then routed to Boynton Slough. The fourth trunk line, an open ditch adjacent and parallel to the east side of Boynton Lane road, collects and conveys storm drainage from the Southeast section of the city.

SPARKS

10. Four storm drain trunk lines and the North Truckee drainage ditch are the main components of the City of Sparks system. North Truckee ditch combined



395
Business
395
McCARRAN
NORTH
NORTH
DITCH
Highland Reservoir
VIRGINIA
TRUNK LINE
NO. 2
TRUNK
STREET
PACIFIC
R.R.
LINE NO. 1
WEST
2ND
STREET
4TH
WEST
SOUTHERN
RIVER
MILL
STREET
80
SOUTH
RENO
SOUTH
GREG
TRUCKEE
TRUNK LINE NO. 5
CALIFORNIA
AVE
LAWTON
HIGTHLAND
TRUCKEE
SO. ROCK
DRIVE
MAYBERRY
McCARRAN
(WEST)
PLUMB
LANE
(EAST)
VIRGINIA
Hunter Creek Reservoir
Virginia Lake
CANNON
INTERNA
AIR PORT
TRUNK LINE NO. 3
Creek
Hunter
BLVD.
EAST PECKHAM
LANE TRUNK LINE NO. 4
SOUTH
McCARRAN
LEGEND
Evans
Creek
Creek
Interstate Highway,
U.S. Highway
Existing Railroad
Foothill line
Trunk Line
395
Dry
Thomas



TRUCKEE MEADOWS INVESTIGATIONS
RENO-SPARKS METROPOLITAN AREA, NEVADA

MAIN STORM DRAINAGE SCHEMATIC
RENO-SPARKS, NEVADA

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

2

FIGURE 3

with North Truckee Drain serves as an irrigation system for ranches and city parks within the environs of the city while North Truckee Drain alone serves as the main storm collector for the area. One trunk line brings storm runoff from areas north of McCarran Boulevard to the North Truckee Drain at Baring Boulevard. The second trunk line, Peoples drain, evacuates storm water from the central and western sections of the city and conveys it to a large gravel pit adjacent to Interstate 80. The water is pumped out of the gravel pit into an open ditch which is routed under I-80; it then discharges into another drainage ditch - the highway trunk line. The highway trunk line is another open ditch that collects storm drain flows between the Southern Pacific Railroad tracks and I-80 plus additional flows from the Southwest corner of Sparks City. The ditch parallels the south side of I-80 until it intercepts North Truckee Drain as it emerges through I-80. North Truckee Drain continues east and south to the Truckee River. See Plate VII for a schematic of the storm drain systems for both cities.

HYDRAULICS

11. The following paragraphs briefly describes some of the hydraulic data such as design flows, freeboard, sedimentation and wind wave data.

PROJECT DESIGN FLOWS

12. The project design flows shown in Table 1 are of the 100-year flood magnitude. Standard Project Flows were also used in the design of flood protection structures. The structures were modified by reducing freeboard, and/or incorporating weir structures and culverts. The purpose of these modifications is to prevent damages that would exceed the pre-project damages

during a flood greater than the 100-year flood because of the presence of the flood control structures. These damages would result from ponding behind levees or floodwalls to depths greater than pre-project, and diversion of flows into areas that were previously dry. Section IV, Design and Construction Considerations, provides a reach by reach description of the modifications.

TABLE 1 - DESIGN FLOWS

Stream	Design Storm Event	Design Discharge (CFS)
TRUCKEE RIVER		
Vista Gage to Steamboat Creek	General Rain	19,900
Steamboat Creek to Entrance Weir	General Rain	12,900
Entrance Weir to Upstream Study Limit	General Rain	18,500
STEAMBOAT CREEK		
Truckee River to Boynton Slough	Cloudburst	9,500
Boynton Slough to Bella Vista Road	Cloudburst	8,050
BOYNTON SLOUGH		
Steamboat Creek to McCarran Boulevard	Cloudburst	8,400

SEDIMENTATION-EROSION-SCOUR

13. A field evaluation and literature search of potential sedimentation and erosion problems within the Truckee River watershed area was completed by personnel of the USCOE Hydrologic Engineering Center (Reference 3). Some of the conclusions of that investigation are that the Truckee River bed through the downtown area of Reno is slowly aggrading and, based on observed pre-project conditions, there appear to be no major sediment related problems along the Truckee River throughout the project area. Possible sedimentation and erosion problems resulting from project features are discussed in Section IV, Design and Construction Considerations.

SEDIMENTATION

14. The Truckee River is a pool and riffle type perennial stream and the channel bed is armored with materials ranging in size from pebbles and cobbles up to boulders several feet in diameter. The prevalence of large-sized bed materials such as boulders decreases from Verdi to Vista and this tendency for decreasing bed material sizes continues past Vista all the way to Pyramid Lake where the dominant grain sizes on the bed are sand and silt. Based on visual observations throughout the project area, there appear to be no obvious sediment related problems in the Truckee River or in the Truckee Meadows tributaries. Localized debris accumulation, beaver activity, and minor aggradation through the City of Reno were observed. These observations are also confirmed by the semiannual operation and maintenance reports from the Carson-Truckee River Conservancy District.

ESTIMATED 100-YEAR FLOOD SEDIMENT PRODUCTION

15. Estimated 100-year sediment production rates were developed. Estimated rates were generated by assuming that the average annual sediment production could be multiplied by a factor obtained from comparing expected magnitudes for single-storm erosion indexes with the average annual erosion index. An exceedance frequency curve was developed using the values and then the "100-year expected single-storm erosion index" was extrapolated from the plot. The ratio of the 100-year value to the average annual erosion index provided a multiplication factor of approximately 12.3. This factor was used to multiply the average annual sediment production rates to produce an estimated 100-year storm sediment of 1.51 million tons and 1.26 million cubic yards total load in the Truckee River passing the Vista gage. The amounts of

sediment are total load estimates. Only a portion of these materials will have the potential to deposit in the project area. Based on the local soil type identified within the watershed, it is estimated that the materials delivered to the Reno and Truckee Meadows areas will be composed of approximately 2 percent gravel, 48 percent sand, 33 percent silts, and 17 percent clays. Therefore, based on these estimated grain size distributions, the potential total average annual amount of sediment available for deposition in the project area would be approximately 50 percent of the total production. Reno could potentially receive as much as 50,000 tons (43,500 cubic yards) of sediment deposits during an average year. Truckee Meadows could receive 61,400 tons (51,300 cubic years) of sediment. This estimate assumes that silts and clays will move through the area without depositing. Using the same material distribution and assumptions, the potential 100-year flood deposit is 755,000 tons (630,000 cubic yards) in the Truckee Meadows area and approximately 615,000 tons (536,000 cubic yards) in Reno.

UTILITIES

16. Type and location of major utility lines crossing over or under the Truckee River between Booth Street and U.S. Highway 395 is presented in Table 2.

TABLE 2 - EXISTING UTILITIES, INLETS AND DIVERSIONS

Location	Type	Description
150 ft± Upstream from Booth Street Bridge	Water	24-inch welded steel under river.
Booth Street Bridge	Gas Telephone	4-inch on bridge. 6, 3-1/2 inch steel conduits on bridge.
Keystone Avenue Bridge	Street Lighting	Power line on bridge.
400 ft± downstream from Keystone	Water	24-inch welded steel under river.
500 ft± downstream from Keystone	Gas	8-inch under river.
Bell Street	Sewage	33-inch RCP under river.
Arlington Avenue Bridge	Street Lighting Telephone	Power line on bridge 9, 3-1/2-inch steel conduits on bridge.
Sierra Street Bridge	Water Gas Power	12-inch steel on bridge. 4 1/2-inch on bridge. Transmission line on bridge.
Virginia Street Bridge	Water Telephone Unknown	8-inch CIP on bridge. 3, 2-inch steel and 9, 6-inch PVC 1, 1-inch and 1, 3-inch on bridge.
Center Street Bridge	Power Telephone Unknown	Transmission line on bridge. 12, 3-1/2 inch steel conduits on bridge. 1, 2-inch and 2, 4-inch pipe on bridge.
Lake Street Bridge	Telephone	6, 3-1/2-inch steel conduits on bridge.
Second Street Bridge	Water	12-inch steel, concrete encased on bridge.
	Gas	4-1/2-inch steel encased as a unit on bridge.
Kuenzli Street Bridge	Power	Transmission line on bridge.
Park Street	Water Gas	12-inch steel under river. 12-inch steel under river.
Locust Street	Sewage	Pipeline suspended over river.

TABLE 2 - Continued

Location	Type	Description
Between Kietzke Lane and Giroux Street	Sewage	Pipeline suspended over river.
Crissie Caughlin Park, N. bank, upstream end	Storm drain	Gated box.
Sumac St. S. bank	Storm drain	12-inch.
Between Sumac St. and Sherwood Dr., S. bank	Storm drain	15-inch.
Sherwood Dr., S. bank	Storm drain	48-inch.
Allen St., S. bank	Storm drain	12-inch.
Ivan Sack Park	Grade control	For irrigation diversion.
Foster Dr., S. bank	Storm drain	48-inch.
Riviera Str., S. bank	Storm drain	12-inch.
Spoon Dr., N. bank	Storm drain	48-inch$\pm$.
Cowan Dr., N. bank	Storm drain	36-inch.
Cowan Dr., S. bank	Storm drain	Size unknown.
Idlewild Park S. bank	Gated diversion	To park lake.
Idlewild Park S. bank	Grade control	Diversion.
Idlewild Park S. bank	Outlet	Lake drain, 24-in CMP.
Idlewild Park S. bank	Lake spillway	Box 4-ft by 8-ft.
Chism St. N. bank	Storm drain	27-inch.
Booth St. upstream S. bank	Unknown	CMP arch.
Vine St. N. bank	Storm drain	21-inch.
Washington St. N. bank	Storm drain	12-inch.
Between Bell & Ralston Sts., N. bank	Storm drain	15-inch.
Arlington Ave. N. bank	Storm drain	Box, 6-ft by 12-ft.
Arlington Ave. S. bank	Storm drain	42-inch.
Sierra St. S. bank	Gated diversion	For Cochran Ditch

TABLE 2 - Continued

Location	Type	Description
Center St. N. bank	Storm drain	30-inch.
Center Street S. bank	Storm drain	12-inch.
Lake St. N. bank	Storm drain	Size unknown.
Lake St. S. bank	Storm drain	Size unknown.
Kuenzli St. S. bank	Storm drain (2)	Size unknown.
Kuenzli St. N. bank	Storm drain	24-inch.
Wells St. N. bank	Storm drain	24-inch.
Wells St. S. bank	Storm drain	30-inch.
Locust St. S. bank	Storm drain	30-inch.
Giroux St. S. bank	Storm drain	12-inch.
Between Giroux St. and Kietzke Ln. S. bank	Storm drain	10-inch.
Between Kietzke Ln. and Hwy 395 N. bank	Storm drain	66-inch.
Between Kietzke Ln. and Hwy 395 S. bank	Storm drain	24-inch.

CHAPTER IV - DESIGN AND CONSTRUCTION CONSIDERATIONS

GENERAL

1. A combination of flood protection structures including set-back levees, floodwalls and enlarged channels will confine a design flow of 18,500 cfs to the main channel of the Truckee River or to the main channel and a small contiguous overbank area through the cities of Reno and Sparks. The flood protective works along Steamboat Creek, Boynton Slough and the Steamboat Marsh area are a series of set-back levees located so as to confine flood flows to the Steamboat Marsh area. A detention basin located on the University of Nevada Experimental Farm will store flood waters from the Truckee River. The purpose of the detention basin is to attenuate downstream flood flows on the Truckee River to or below pre-project flows in order not to increase downstream flood damages.

2. In order to minimize impacts upon the recreation areas, levees and floodwalls were set back and the alignment determined by considering the location of significant features such as landscaping, natural vegetation, recreation paths, buildings, picnic areas and adjacent land-use. Floodwalls are located in some areas where construction of levees would be impractical because of limited available land area or costly facility replacement. Aesthetics were also considered; as an example of this, gabion floodwalls were incorporated in the design on the north bank of the Truckee River between Booth Street and Wingfield Park and aligned so as to blend in with an existing gabion floodwall. See Plate XI, Section R.M. 52.96

3. Channel excavation was limited to that which is absolutely necessary in order to pass the design floodflows. Careful hydraulic analyses limited the number of excavation sites to four on the Truckee River and none on either of the tributaries. On the Truckee River one site is near Booth Street, another is around both channels at Wingfield Park Island, another along Glendale Park and the last at the University Farms inlet weir near McCarran Boulevard. Excavation is limited to the north bank except around Wingfield Park and at the inlet weir.

ENVIRONMENTAL CONSIDERATIONS

4. Environmental features incorporated in the project are discussed in the following subparagraphs.

TRUCKEE RIVER

5. Levees and floodwalls are set-back on an alignment that will cause the least impact upon bicycle paths, recreation areas such as parks, commercial and private developments, and existing features such as trees, shrubberry and other natural and induced vegetation. Floodwalls above Arlington Avenue consist of gabions and small inverted T floodwalls appropriately situated so as to complement the existing gabion and concrete floodwall system. Channel excavation is confined to the north bank to minimize the removal of tall vegetation on the right bank. The vegetation on the right bank is important as it shades the river.

STEAMBOAT CREEK AND BOYNTON SLOUGH

6. Natural features of each channel are retained. The Pembroke Drive bridge will be replaced. All levees are setback along the periphery of the marsh.

LEVEES

7. Proposed levees have a crown width of 12 feet (32 feet for Pembroke Drive segment of the left Boynton Slough Levee), sideslopes of 1V to 3H waterside and 1V to 2H landside. Maximum levee height is about 15 feet and an aggregate base patrol road will be constructed on the levee crown (except Pembroke Drive Levee segment will have an asphaltic road). Setback levees are utilized along the Truckee River and they are located with a minimum of 20 feet from the toe of the levee to the intersection of the excavated channel and natural ground, or adjacent to the natural bank if there is no channel excavation. Levees are the primary flood protection structures except where limited space or esthetics requires floodwalls.

LEVEE STABILITY

8. A stability analysis was performed on both slopes of the design levee. The analysis was completed on side slopes of 1V to 3H for the waterside slope and a 1V to 2H slope on the landside slope. Foundation soil weights and strength parameters were selected using the lowest soil test values from the available data. Levee soil weights and shear strengths were selected using typical weights and shear strengths for compacted silty sand materials. Controlling conditions were sudden drawdown on the waterside and steady

seepage on the landside. The resulting factor of safety values were 1.28 and 1.62 for waterside and landside slopes, respectively. Minimum factors of safety recommended in EM 1110-2-1913 are 1.0 and 1.4 respectively. Earthquake loadings were not analyzed because of the low probability of simultaneous occurrence of both events.

SEISMICITY AND LIQUEFACTION POTENTIAL

9. Reno and Sparks are located in seismic probability zone 3, a zone designated as a major damage area. A Richter magnitude 5.3-5.4 event is projected to occur within 20 miles of Reno once in 30 years and an earthquake of magnitude 7 or greater within 62 miles once in 70 to 80 years. Loose foundation sands, high ground-water, and the seismic potential both in intensity and frequency indicate that liquefaction potential is high. Foundation soils in the area east of McCarran Boulevard and adjacent to the river could cause moderate slumping of levee slopes (loose sands, imported fill) and little slumping for levees located west of McCarran Boulevard or south of the immediate Truckee River area (sandy silt to clayey soils). The joint probability of an earthquake during pool storage is very low for the University Farms overflow area.

SETTLEMENT

10. Along the Truckee River levee settlement during and after construction is negligible. Total levee foundation settlement is estimated to be 6 inches, almost all of which will occur during construction. Levee foundation settlement in the Steamboat Marsh and University Farms overflow area is

estimated at 2 inches over a ten year post-construction time. Very little settlement should occur during construction.

BEARING CAPACITY

11. The estimated maximum design bearing capacity of the soils in the University Farms overflow area entrance weir location is 2.5 tons per square foot because of loose silty sand, and 0.5 tons per square foot in the exit weir location because of one or more layers of a very soft clay. A concrete key extending 10 to 12 feet below the entrance weir structure is required in order to minimize differential settlement, and dewatering of the site will be required during construction. A series of observation wells will be installed along the retention basin levee alignment so that a record of ground-water conditions can be obtained prior to construction.

SEEPAGE

12. Seepage is expected to be minimal throughout the levee system. The expected pool duration in the detention basin of one to two weeks is not sufficient to create a seepage condition either through or below the levee and flow duration along the setback levees on Steamboat Creek and the Truckee River are no longer than three to four days. Levee foundation soils in the Steamboat and the detention basin are clayey materials of low permeability.

FLOODWALLS

13. Reinforced concrete floodwalls are of two different types. One type floodwall is an inverted T constructed on a set-back or along an existing

bank. The height above ground will vary from 0 feet to approximately 8 feet maximum above ground. See Plate XI. The other type floodwall is a poured-in-place vertical wall with a 5-foot deep steel sheet cut-off extending below the wall. This type floodwall will be constructed adjacent to existing floodwalls in the downstream Reno area. The new wall will buttress the old and will be anchored by soil anchors penetrating through the old wall into firm ground behind. See Plate XI. A third type of floodwall will consist of rock and wire gabion baskets laced and stacked to form the wall.

CHANNELS

14. Priority was given to maintaining as much of the Truckee River and the two tributaries, Steamboat Creek and Boynton Slough in their present natural conditions as much as possible. Setback levees and/or floodwalls are the primary design methods used. Channel excavation was limited to one bank side and the excavated bottom was benched above the normal low water channel. Channel excavation is required along the north bank of the Truckee River between Booth Street and Keystone Avenue, around the north and south sides of Wingfield Park Island, and upstream of Glendale Park plus the approach channel to the inlet weir on the University Farms overflow area. No channel excavation is necessary on either of the tributaries. Excavated channel slopes will be protected by revetment.

BRIDGES

15. Seven bridges will be replaced along the Truckee River in Reno. These seven bridges are the major obstructions to the design floodflow through the city. Several alternatives to bridge replacement were analyzed but were

economically unacceptable. One bridge, Pembroke Lane, will be replaced on Steamboat Creek. The center span of Wells Avenue Bridge will be inundated by 1 foot of water at project design flows, however, resultant backwater is not detrimental and the bridge is expected to stay intact. See Table 3 for further details on the bridges that will be replaced.

TABLE 3 - BRIDGE REPLACEMENT DATA

Location	Length (feet)	No of Piers	Freeboard (feet)
TRUCKEE RIVER			
1. Booth Street	120	2	1.0*
2. N. Arlington Avenue	128	2	3.5
3. S. Arlington Avenue	46	0	1.5
4. Sierra Street	130	2	2.0
5. Virginia Street	152	2	1.5
6. Center Street	174	2	1.5
7. Lake Street	161	2	1.5
STEAMBOAT CREEK			
1. Pembroke Drive	800	16	2.0

*Minimum freeboard

DETENTION BASIN

16. To ensure project flows downstream from the project area do not exceed the preproject flows, an off-river detention basin is will store flows diverted from the Truckee River for later release after passage of the flood peak. The 100-year preproject flow at the Vista stream gage is 19,900 cfs and this flow was the controlling discharge in the design and sizing of the detention basin and its appurtenant features. The detention basin is located in the University Farms area. It is bounded on the north by the Truckee River, on the east by the Steamboat Creek overflow area, on the south by Pembroke Drive, and on the west by McCarran Boulevard. Existing ground

elevations in the overflow area range from elevation 4,380 up to elevation 4,390. Levees are necessary around the entire detention basin to separate stored water from the Truckee River and Steamboat Creek floodflows and also to developed areas to the west. Truckee River flows would be diverted to a weir near the upstream end of the overflow area approximately 1,000 feet downstream from McCarran Boulevard on the right bank. Floodflows would be permitted to leave the detention basin over a lower weir located on the eastern boundary of the detention basin. A gated low level outlet is provided for complete drainage of the detention basin.

INLET WEIR

17. The upper weir or inlet weir is located in line with the north levee of the detention basin which is contiguous to the right bank of the Truckee River.. Hydraulic design of the upper weir was based on a combined hydraulic and hydrologic steady flow analysis using the HEC-2 and HEC-1 programs, respectively. Based on these analyses, a 1,000 foot-long sharp crested weir is used with a crest elevation of 4394.2; an elevation equivalent to the water surface on the Truckee River at a discharge of 10,500 cfs. All Truckee River flows of less than 10,500 will flow undiverted past the weir. All flows greater than 10,500 cfs will have a portion of the flow diverted into the detention basion. The peak discharge over the weir during project design flood is 5,600 cfs. The peak stage in the detention basin during the project design flood is elevation 4395.1 feet. The undiverted flow past the upper weir during the project design flood is 12,900 cfs. The design of the stilling basin for the upper weir is based on a USBR Type IV stilling basin with Froude numbers less than 4.5. An approach channel will be excavated along the entire length of the weir. The approach channel is necessary for

two reasons, one, to slow channel velocities down in the river, the other, to redirect flows into the weir. The nose section of the levee at each end of the weir will be armored for 200 feet on both slopes because strong eddy currents are probable around the extremities of the weir. The approach channel floor and the downstream floor of the weir will also be armored.

OUTLET WEIR

18. The purpose of the lower weir is to provide a means of discharging excess storage water from the detention basin during floods. The hydraulic design of the weir is based on maximizing the discharge efficiency of the weir, while minimizing backwater effects upon the upper weir. The lower weir is located on the eastern boundary of the detention basin. Based on the hydraulic and hydrologic analyses, a sharp-crested weir with a crest length of 250 feet at elevation 4393.0 is used. The peak discharge over the lower weir during the project design flood is 3,000 cfs. The stilling basin design is based upon USBR Type IV basin using a design discharge of 3,000 cfs.

LOW LEVEL OUTLET

19. A low level outlet is provided along the eastern boundary levee of the overflow area approximately 2,500 feet north of Pembroke Lane on an existing drainage channel. The purpose of the low level outlet is drainage during nonflood conditions and sump drainage of the detention basin after flood storage depletion. The lower level outlet consists of two 48-inch reinforced concrete pipes with an entrance invert elevation of 4379.5 feet. Each conduit

is separately controlled by a manually operated gate in addition to flap gates at the downstream end. The low level outlet will empty into the Steamboat Creek area.

DETENTION BASIN LEVEES

20. The levee system ringing the detention basin is a compacted earth structure averaging 10-feet in height with sideslopes of 1V to 3H on the storage side, 1V to 2H on the landside, a 12-foot crown width and an aggregate base patrol road on the crown. Patrol road access is provided at Pembroke Drive and McCarran Boulevard for the western, southern, and a portion of the east levee (from the southeast end of the levee north to the lower weir). There is no patrol road access to the northeast segment and the entire north levee. Kimlick Lane traverses through the detention basin and is the only access road to the Reno-Sparks sewage treatment plant. The road would be inundated during detention basin storage; however, alternative access to the sewage plant is possible along the eastern boundary of the Steamboat marsh area. A 12-inch layer of rock will be placed on the storage sideslopes for the entire length of the east and north levee segments.

21. Freeboard for the levee system is 3 feet for the western and southern segments and 2 feet for the eastern and northern segments. A lower freeboard is utilized on the north and east segments so as to provide initial overtopping into the Steamboat marsh area away from developed areas.

DIVERSION STRUCTURES

22. Diversion structures in the study area were constructed to divert water for agricultural and municipal water uses. There are two diversion structures at Wingfield Park, one on each of the two channels going around the park island. The channel around the island will be excavated and the dams will be replaced. The next diversion dam on the Truckee River located at Glendale Avenue is the primary water supply source for the City of Sparks and a few ranches. The dam will be removed and a replacement constructed further upstream and the supply ditch rerouted to the new dam. The two remaining diversion dams on the Truckee River, one about 500 feet upstream from Greg Street and the other located about midway between Greg Street and South Rock Boulevard, will remain in place. Ivan Sack Dam, located in the western part of Reno on the Truckee River, was at one time a diversion structure for an irrigation system for several ranches in the area, however, the dam is completely silted up and the irrigation system is no longer used. Recently, the City of Reno publicized their intention to remove the dam and the silt in order to improve the hydraulic efficiency of the river. Strong opposition to the removal has terminated the plan.

LEVEES AND BRIDGES - STEAMBOAT CREEK AND BOYNTON SLOUGH

23. Maximum water surface elevations on the two tributaries are the result of backwater effects from the 100-year general rain flood (the design flood) on the Truckee River and concurrent floodflows in Steamboat Creek and Boynton Slough. The combined floodflows cause backwater in the Steamboat Marsh above Pembroke Drive. The marsh area will remain in its present state and setback

levees will be constructed at locations on the periphery of the marsh. The levees will protect a housing development in the southeast section of Reno and the Hidden Valley residential area on the east side of the marsh. The levees average 12 feet in height on Boynton Slough and 8 feet on Steamboat Creek. The left levee of Steamboat Creek merges into the right levee of Boynton Slough and this levee terminates at McCarran Boulevard. The left levee of Boynton Slough begins at McCarran Boulevard follows the slough alignment to a compound curve on Pembroke Drive. It then follows the Pembroke Drive alignment to Steamboat Creek. Pembroke Drive will be relocated onto the levee crown. Pembroke Drive Bridge spanning Steamboat Creek will be replaced by a long (700-800 feet) multi-pier bridge. The long span is necessary to prevent excess ponding below Pembroke Drive and unrestricted flow into and out of the marsh area above Pembroke Drive. Levee cross-section design is the same as for the Truckee River.

EROSION PROTECTION

24. A 15-inch layer of rock will be placed on the exposed slopes of all excavated channels on the Truckee River. This is necessary because of high flow velocities. On Steamboat Creek a 1,000 foot reach will require a 15-inch layer of rock. The eroding site is on the outside bend of a meander curve. Additional erosion could endanger a number of homes located on Pelham Drive. The approach and exit channel sideslopes to all bridges not suitably protected against scour will receive a protective layer of graded rock designed to a toe-in-depth equal to the estimated scour depth. All bridge piers extending into the channel will also be protected against scour by a surrounding layer of stone. Windwave protection is necessary on the north and east waterside banks of the University Farms detention basin levee. A 12-inch layer of rock

will be adequate. No protection is necessary on the west and south levees as the prevailing design wind is from the southwest. The entrance and exit weir approach and discharge channels will also be protected by rock.

CHANNEL STABILITY

25. The Truckee River is not a braided stream; it is not wide enough or shallow enough, it doesn't contain numerous sand bars or islands, and it doesn't meander very much. Natural bank width varies from 150 to 200 feet for the entire length between West Reno and the Vista stream gage. Average natural bank heights range between 6 and 12 feet.

26. Steamboat Creek channel originates about mid-way between Pembroke Drive and the Bella Vista Ranch road in the middle of the marsh. The channel is shallow but well defined with a moderate meander down to Pembroke Drive. Below Pembroke Drive Steamboat Creek continues in a moderate meander pattern but the creek progressively deepens and the banks steepen to vertical. Average bank heights below Pembroke are 12 to 15 feet, and above Pembroke are 5 to 8 feet. Boynton Slough channel between McCarran Boulevard and Steamboat Creek is shallow, but well defined with a moderate meander.

CHANNEL VELOCITIES

27. Floodflow velocities on the Truckee River are high. They range from 8 to 16 feet per second through the Reno area to McCarran Boulevard, then decrease to a range of 6 to 12 feet per second below McCarran Boulevard. HEC-2 hydraulic analysis indicates no significant water surface instability at these high velocities. Undoubtedly, the diversion-weir dams contribute greatly to

the river stability. Manning's "n" values used for the velocity profiles were 0.030 feet for the channel and 0.038 for the overbank.

28. Velocities ranging to a maximum of 10 feet per second on Steamboat Creek and 6 feet per second on Boynton Slough were computed using the same "n" values as were used on the Truckee River. Overbank velocities on the Truckee River and the tributaries average 3 feet per second.

APPROACH AND EXIT CHANNELS

29. The beginning of all flood control structures are tied into high ground or tapered into existing structures. On the Truckee River the upstream end of the flood protection works on the left bank consists of a floodwall tied into high ground of the Booth Street Bridge approach embankment, while the right upstream end begins with a tie-in to a high bluff located halfway between Keystone Avenue and Arlington Avenue. Both floodwalls within this reach end at the upstream end of Lake Street Bridge abutment. There are no flood control structures between Lake Street and Glendale Avenue on the left bank or between Lake Street and Kietzke Lane on the right bank. Flood control structures are continuous between Glendale Avenue to the vicinity of the North Truckee Drain on the left bank and between Kietzke Lane and the University Farms overflow levee on the right bank. The downstream end of the left levee ties into the road embankment of Interstate I-80 near the mouth of North Truckee Drain, while the right levee adjoins the ring levee around the University Farms overflow detention basin. Setback levees on Boynton Slough and Steamboat Creek also tie into high surrounding ground or adjacent bridge approach embankments.

WATER SURFACE PROFILES

30. Water surface profiles for the project were computed by the standard step method using Manning's "n" values for channel roughness and the computer program HEC-2 Water Surface Profiles. Profiles were determined by using maximum expected "n" values to obtain maximum stage, and minimum expected "n" values to obtain maximum channel velocities. Where excavation is planned, Manning's "n" values of 0.035 for the channel and 0.045 for the overbanks were used. Minor losses used in computing water surface profiles were transition and bridge pier losses. Loss coefficients of 0.1 and 0.3 were used for channel contractions and expansions, respectively. Loss coefficients of 0.34 and 0.50 were used for bridge contractions and expansions, respectively. A pier-shape coefficient equal to 0.90 was used to compute losses for the bridges. Starting water surface elevations for the Truckee River are based on the stage-discharge rating curve for the Vista Stream Gage at River Mile 43.87.

FREEBOARD

31. The purpose of a freeboard allowance is to provide for those factors that cannot be rationally accounted for in design flood profile computations (EM 1110-2-1913, Design and Construction of Levees) and to ensure that the desired degree of protection will not be reduced by unaccounted factors such as erratic hydrologic phenomena, future development of urban areas, unforeseen embankment settlement, silt accumulation, debris, aquatic and other growth, and other variations in channel roughness (EM 1110-2-1601 Hydraulic Design of Flood Control Channels). Both engineering manuals recommend a 3-foot freeboard allowance for urban levees and floodwalls. Additional increases

from one half to one foot is also recommended at constrictions, approaches to bridges, and the upstream end of flood protective works.

32. Since the design flood protection level is less than the SPF, then floods exceeding the 100-year event can overtop the levees or floodwalls and be directed into areas that were not flooded prior to project construction. Project features have been designed to allow floodwaters in excess of design capacity to escape the river safely at predetermined locations. Excess floodwaters would spill into overbank areas that would have flooded prior to the project. To ensure this, each weir crest elevation is one foot above the 100-year flood elevation and minimum freeboard is three feet between each levee or floodwall segment connecting each weir. The weir site is selected to direct flows into a specific area and the weir length sized for a flow not to exceed the pre-project SPF overland flow calculated for the specific area. The minimum of three feet freeboard between each weir is to ensure positive flow through each weir without overtopping between each weir. Freeboard exceeding three feet up to a maximum of six feet is incorporated on some segments in order to preclude catastrophic overtopping into populated areas by SPF flows. See Table 4 for additional freeboard information.

33. Historically, floods have overtopped both banks of the river in the vicinity of Booth Street-Arlington Avenue. Flows along the north (left) bank pass through the main downtown area of Reno continuing generally parallel to the river re-entering the river near US-395 highway. South (right) overbank flows diverge from the river in a southeast direction merging with additional overflow northwest of Cannon Airport. Other overbank flows occur near US-395 highway and the MGM hotel-casino complex, the north bank flows continue

parallel to the river finally ponding in the Sparks industrial-warehouse area and along the North Truckee Drain area in east Sparks. South breakout flows pond in the Steamboat Marsh and the University Farms areas.

TABLE 4

LEVEE AND FLOODWALL FREEBOARD ABOVE DESIGN FLOOD (100-YEAR EVENT)

From	To	Left Bank	Right Bank
Booth	Arlington	1'	1'
Kietzke	Glendale	*	3'-5-1/2'
Glendale	Greg	1'-3'	1'-3'
Greg	So. Rock	3'-3-1/2'	1'-3-1/2'
So. Rock	McCarran	1'-4'	1'-3'
McCarran	End of Project	4'-6'	3'-4-1/2'

*Natural bank height higher than 3 feet above design water surface.

INTERIOR DRAINAGE

34. There are two types of interior drainage flows associated with the project. One is the backup of storm drainage flows into the protected areas. Flow backup will occur when flood stages at the discharge outlets located along the Truckee River, Steamboat Creek and Boynton Slough exceed the outlet level. Each outlet will contain a one way automatic flap gate to prevent reverse flow. The other interior drainage problem is the ponding of storm flows caused by closure of the flap gates at high stages and the ponding of overland flows behind the flood protection works. Ponding mitigation is as follows:

(1) The addition of two 100 HP pumps to the existing pumping plant at the Helms gravel pit retention basin. The outlet from the existing pumping

plant discharges into an open channel which in turn discharges into the North Truckee Drain. The additional pumping capacity is installed to mitigate for the decrease in outlet flow at the North Truckee Drain caused by actuation of the one way flow devices at the Drain discharge. The additional pumping plant will discharge into a pipe that will bypass the North Truckee Drain and discharge directly into the Truckee River.

(2) Three 100 HP pumps contained in a common sump will be installed at the North Truckee Drain outlet. Pipes leading up over the levee system will convey the pumping plant discharge into the river. See Table 5 for interior ponding volume.

OVERTOPPING

35. Culverts located along the left levee of Boynton Slough and the levee within the Sparks industrial-warehouse area will convey overtopping flows back to the Steamboat overflow area and the Truckee River respectively. Design features include invert elevations set slightly above the 100-year channel flood elevation, flap gates to prevent back flow and a manually operated positive closure gate. See Table 5 for overtopping volumes.

TABLE 5
PONDING AREA VOLUME

Ponding Area	Ponding Volume* Interior	Overtop
Helms Gravel Pit	7,200	-
Sparks Warehouse Area	12,000	7,900
Southeast Reno	-	6,100

*Acre-Feet

WIND WAVES

36. Windwave erosion is probable on the University Farms overflow retention levee structure. No long-term wind data was available other than the general prevailing wind direction for the winter season. This was obtained through the NWS (National Weather Service) office at Cannon International Airport. Computations for the windwave erosion protection requirements were obtained by methods contained in ETL 1110-2-221, "Wave Runup and Wind Setup On Reservoir Embankments" and ETL 1110-2-222, "Slope Protection Design for Embankments In Reservoirs".

CONSTRUCTION TIME

37. The average construction season for this type of project will probably begin in April and end during the first half of November, with no construction during the winter season. Traffic through the downtown Reno area is heavy during the tourist season (June through August). Five of the seven bridges to be replaced are in the center of the congested area. Bridge removal and replacement based upon an April to November construction season, stringent water quality standards, and the existing traffic situation will require about 1-1/2 years for each bridge. The estimated total construction time is six years.

CONSTRUCTION MATERIALS

38. All of the basic materials necessary for construction of the project such as sand, cement, soil embankment, and rock are available within 10 miles of the construction area. Sand and cement is available and production capacity

for concrete is adequate for the entire project from local concrete and construction companies. Embankment material is available from a borrow site identified as the Mira Loma Borrow Pit located south of the project area. The borrow pit is under the control of the State of Nevada Department of Transportation and the pit capacity is estimated at 10 to 15 million cubic yards while total project requirements are estimated at about 1 million cubic yards. Streambed cobbles are too rounded for use as erosion protection; however, they are suitable for gabion basket fill. Rock meeting design standards is available from a quarry site near the eastern outskirts of Sparks near Interstate I-80. The quarry is owned by the Southern Pacific Transport Company and operated by Helms Construction Company. Capacity of the quarry is estimated far in excess of the estimated 50,000 tons required for the entire project. See Appendix for the quarry and borrow locations.

CARE OF WATER

39. There are several areas along the Truckee River that will require a temporary diversion of water during construction. A brief description of each is provided in the following paragraphs.

40. Floodwalls through Reno from Sierra Street to Lake Street. A temporary sheet-piling diversion wall will be constructed along each side of the river between Sierra and Lake Streets. The area behind the wall will be dewatered and excavated for poured-in-place floodwalls. The same procedure will be utilized for floodwalls to be constructed at the Edison Way Industrial Park located on the right bank of the Truckee River between South Rock Boulevard and McCarran Boulevard, and for another floodwall adjacent to the Dominican Brothers Monastery.

41. Wingfield Park. Flow around Wingfield Park will be diverted to one channel by a cofferdam located upstream and downstream of the construction site and the construction accomplished. Each channel around the island will be excavated across the full bottom width.

42. The construction site for the inlet weir to the overflow detention basin will require diversion of flow, again by a cofferdam. Excavation will be in loose sand; therefore, careful design of the cofferdam suitable for the expected conditions will be required.

CARE OF TRAFFIC

43. Each bridge replacement will require diversion of traffic during removal and replacement of the bridge. In the downtown area of Reno the problem is one of diversion to adjacent streets only. No extensive traffic signal system will be required. The north-bound lanes of McCarran Boulevard between Pembroke Drive and the Truckee River will require a traffic signal system while construction equipment is in operation and traffic on Kimlick Lane routed to a temporary lane across the construction site of the west levee of the detention basin. Pembroke Drive will be rerouted to a temporary road during construction of the Pembroke Lane segment of the left Boynton Slough levee and a temporary bridge placed across Steamboat Creek.

MAINTENANCE AND INSPECTION

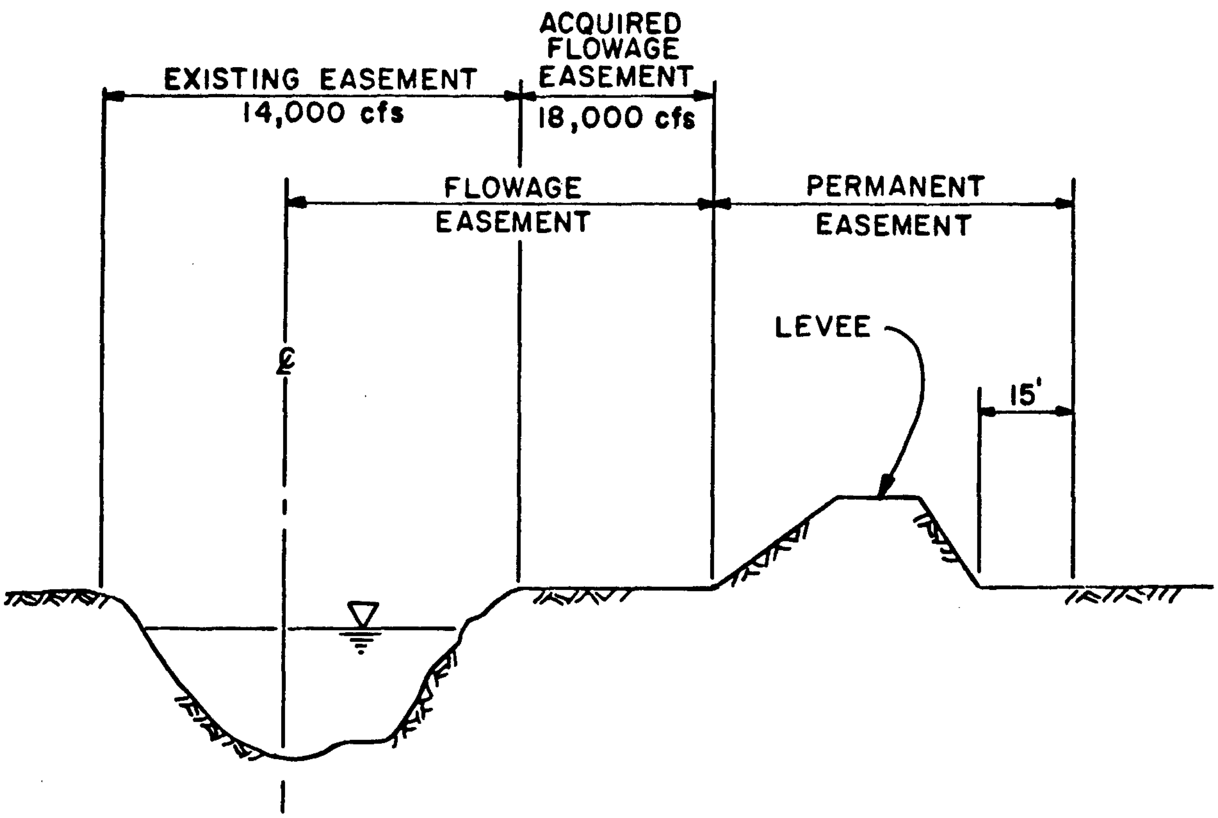
44. The cities of Reno and Sparks are responsible for the maintenance required to insure integrity and functioning of all flood control features of the project. This includes a systematic inspection of all components of the

flood control system and operational testing of components such as pumps and control gates.

REAL ESTATE COSTS

45. The estimates of land and improvement values are based upon sales, listings, and opinions of local people knowledgeable in real estate and they are assumed to be valid for one year after the valuation date of 17 March 1982. The contingency percentage includes severance damage estimates, and allowance for appreciation and minor project design changes. Acquisition costs are based upon $3,500 per ownership.

46. Two types of easements were evaluated. One, a permanent easement to be used for levee or floodwall construction plus a permanent access easement 15 feet wide located adjacent to the landward side of the construction easement. The other is a flowage easement for the area between the levee (floodwall) right-of-way and the river. See Plate 2. The value of the permanent easement and the flowage easement along the Truckee River will be fee value of the lands because of the limitations placed on land-use. These areas are floodways and as such no improvements, excavation, or landfilling is permitted. The cost of lands to the project has been reduced by the value of lands already provided under the Truckee River and tributaries project. Under this project locals provided lands for a channel capacity of 14,000 cfs. Therefore the costs for flowage easements and lands include any flat area applicable to the increase in design flow from 14,000 to 18,500 cfs.



TRUCKEE MEADOWS INVESTIGATION
(RENO-SPARKS METROPOLITAN AREA)
NEVADA

SKETCH-REAL ESTATE
EASEMENTS

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
FEBRUARY 1983

FIGURE 4

47. The value of the flowage easement for the detention basin and the overflow area precludes new construction of improvements and excavation or landfill by the landowner, reserving to the owner all other rights not inconsistent with the purposes of the easement. Both of these areas are currently used for agricultural purposes. Even though the areas could have other utilization, the poor water quality, high water table and fill required for development would restrict most economical industrial and residential speculation. The elimination of all new construction would halt any possible future development of the areas. Under these conditions the flowage easement is estimated as 25 percent of fee value.

PROJECT COSTS

48. Project costs were estimated in accordance with appropriate EM's in the 1110 series and include the cost of all work and materials necessary for a complete job. The estimates of first and annual costs are based on 1 October 1982 prices and annual costs are based on a 7-7/8 percent interest rate and a 50-year amortization period. Unit costs were based on site conditions, quantities, type of material to be hauled, length of haul, and size of contract. Abstracts for bids for similar contracted work were used along with information obtained from manufacturers and contractors. A 20 percent contingency allowance is included in order to provide for unknowns in foundation conditions, borings, surveys, and other uncertainties. The value of the contingency allowance is based on the estimators judgment and the stage of planning. The total first cost of construction is divided into two parts; Federal and non-Federal. The Federal part consists of all costs associated with direct flood protection such as floodwalls, levees and channel modifications. Non-Federal costs contain non-direct construction costs such

as land and the associated improvements, easements, utility replacements and relocations, and modification or replacement of bridges. See Tables 6 and 8.

49. Annual costs (Table 7) include amortization of construction costs over the project life and O&M costs representing the estimated cost to maintain the project throughout the project life including salaries, supplies, supervision and inspection.

MAINTENANCE AND OPERATION COSTS

50. The estimated operation and maintenance costs represent the average economic cost to maintain the project throughout the project life. The maintenance costs for levees and channels, flood control structures, etc. are based on known expenditures for similar projects. These costs include personnel salaries, supplies, supervision, inspection and overhead costs and major component replacement during the project life.

TABLE 6

SUMMARY OF FIRST COSTS

	FEDERAL	NON-FEDERAL
LEVEES	6,820,000	
Engineering & Design	750,000	
Supervision & Administration	560,000	
FLOODWALLS	8,340,000	
Engineering & Design	920,000	
Supervision & Administration	680,000	
CHANNELS	710,000	
Engineering & Design	80,000	
Supervision & Administration	60,000	
PUMPING PLANT	1,200,000	
Engineering & Design	130,000	
Supervision & Administration	100,000	
DIVERSION STRUCTURES	1,220,000	
Engineering & Design	130,000	
Supervision & Administration	100,000	
LANDS & DAMAGES		13,400,000
RELOCATIONS		11,200,000
Engineering & Design		1,230,000
Supervision & Administration		930,000
UTILITIES		3,050,000
Engineering & Design		340,000
Supervision & Administration		250,000
SUBTOTAL:	$21,800,000	$30,400,000
TOTAL PROJECT FIRST COST		$52,200,000

All numbers are rounded

TABLE 7

SUMMARY OF ANNUAL COSTS

FEDERAL INVESTMENT	
Interest	$1,720,000
Amortization	50,000
TOTAL FEDERAL ANNUAL COST	$1,770,000
NON-FEDERAL INVESTMENT	
Interest	$2,390,000
Amortization	64,700
Maintenance & Operation	
Detention Basin	50,000
Levees	29,000
Bank Protection	2,000
Pumping Plant	54,000
TOTAL NON-FEDERAL ANNUAL COST	$2,590,000
TOTAL PROJECT ANNUAL COST	$4,360,000

All numbers are rounded

TABLE 8

DETAILED ESTIMATE OF FIRST COST

FEDERAL COST

COST ACCT NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
11	LEVEES				
	Clearing & Grubbing	1	JOB	LS	$30,800
	Embankment	814,000	CY	3.50	2,849,000
	Excavation (Inspection trench	105,000	CY	1.60	168,000
	Excavation (Waste)	76,600	CY	1.00	76,600
	Aggregate - Patrol Road	20,200	TON	10.00	202,000
	Fencing	53,300	LF	9.00	479,700
	Seeding	93	AC	400.00	37,200
	Water (Compaction & Dust)	56,300	M-GAL	6.00	337,800
	Excavation	78,800	CY	1.60	126,080
	Rock	50,100	TON	15.00	751,500
	Grout	810	CY	100.00	81,000
	Care & Diversion of Water	1	JOB	LS	25,000
	Culverts	1,230	LF	60.00	73,800
	Care of Traffic	1	JOB	LS	42,000
	Gabions	4,400	CY	90.00	396,000
	Subtotal				$5,676,480
	Contingencies (20%±)				$1,143,520
	Total Levees				$6,820,000
11	FLOODWALLS				
	Clearing & Grubbing	1	JOB	LS	2,600
	Excavation	14,800	CY	8,00	118,000
	Formed Concrete	18,800	CY	180.00	3,384,000
	Cement	87,800	CWT	4.50	395,100
	Reinforcing Steel	755,000	LBS	0.50	1,510,000
	Sheet Piling	15,600	SF	15.00	234,000
	Soil Anchors	1	JOB	LS	908,000
	Rock	3,080	TON	15.00	46,500
	Grout	315	CY	100.00	30,000
	Fencing	2,800	LF	9.00	25,200
	Seeding	5	AC	400.00	2,000
	Care & Traffic	1	JOB	LS	100,000
	Care & Diversion of Water	1	JOB	LS	185,000
	Subtotal				$6,940,400
	Contingencies (20%±)				$1,399,600
	Total Levees				$8,340,000
9	CHANNELS				
	Clearing & Grubbing	1	JOB	LS	3,000
	Excavation	70,600	CY	3.30	232,980
	Rock	12,500	TON	15.00	187,500
	Seeding	2	AC	400.00	800
	Care & Diversion of Water	1	JOB	LS	170,000
	Subtotal				$594,280
	Contingencies (20%±)				$115,720
	Total Channels				$710,000

All numbers are rounded

TABLE 8 (Cont'd)
FEDERAL

COST ACCT NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
13	PUMPING PLANT	1	JOB	LS	$1,000,000
	Contingencies (20%±)				200,000
	Total - Pumping Plant				$1,200,000
15	DIVERSION STRUCTURES				
	Upper Weir	1	JOB	LS	$638,000
	Lower Weir	1	JOB	LS	278,000
	Lower Level Outlet	1	JOB	LS	103,000
	Contingences (20±)				201,000
	Total - Diversion Structures				$1,220,000
30	ENGINEERING & DESIGN				
	Levees				$750,000
	Floodwalls				917,000
	Channel				78,500
	Pumping Plant				132,000
	Diversion Structures				134,000
	Total - Enginering & Design				$2,010,000
31	SUPERVISION & ADMINISTRATION				
	Levees				$546,000
	Floodwalls				667,000
	Channels				57,100
	Pumping Plant				96,000
	Diversion Structures				97,600
	Total - Supervision & Administration				$1,460,000
	TOTAL FEDERAL FIRST COST				$21,800,000

All numbers are rounded

TABLE 8 (Cont'd)
NON-FEDERAL COST

COST: ACCT: NO.:	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
	LANDS & DAMAGES				
	Permanent Easements				
	Residential	2	AC	75,000	$150,000
	Commercial	17	AC	175,000	3,070,000
	Agricultural	90	AC	10,000	900,000
	Temporary Easements				
	Residential	2	AC	3,500	7,000
	Flowage Easements				
	Agricultural	1,780	AC	2,500	4,450,000
	Improvements				
	Commercial	1	JOB	LS	1,230,000
	Public Parks	1	JOB	LS	137,000
	Relocations	1	JOB	LS	135,000
	Acquisition	63		3,500	221,000
	Waste Disposal Area	1	AC	10,000	10,000
	Subtotal				$10,310,000
	Contingencies (30%±)				$3,090,000
	Total - Lands & Damages				$13,400,000
	RELOCATIONS				
	Roads	1	JOB	LS	55,000
	Bridges				
	Booth Street	1	JOB	LS	515,000
	Arlington Avenue	1	JOB	LS	1,230,000
	Wingfield Park Ped.	1	JOB	LS	50,000
	Lake Street	1	JOB	LS	1,170,000
	Center Street	1	JOB	LS	1,230,000
	Virginia Street	1	JOB	LS	1,100,000
	Sierra Street	1	JOB	LS	960,000
	Pembroke Drive	1	JOB	LS	2,720,000
	Diversions (City of Sparks)	1	JOB	LS	325,000
	Subtotal				$9,355,000
	Contingencies (20%±)				$1,845,000
	Total - Relocations				$11,200,000
	UTILITIES				
	Service - Gas, Water, Sewage	1	JOB	LS	$515,000
	Irrigation Ditch	1	JOB	LS	35,000
	Telephone	1	JOB	LS	1,990,000
	Subtotal				$2,540,000
	Contingencies (20%±)				340,000
	Total - Utilities				$3,050,000

All numbers are rounded

TABLE 8 (Cont'd)
NON-FEDERAL COST

COST ACCT NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
	ENGINEERING & DESIGN				
	Relocations				$1,230,000
	Utilities				336,000
	Total - Engineering & Design				$1,570,000
	SUPERVISION & ADMINISTRATION				
	Relocations				$930,000
	Utilities				250,000
	Total - Supervision & Administration				$1,180,000
	TOTAL NON-FEDERAL FIRST COST				$30,400,000
	TOTAL PROJECT FIRST COST				$52,200,000

All numbers are rounded

References.

1. Office Report - Truckee River, California and Nevada, USCOE, Sacramento District, February 1980 (Hydrology).

2. Flood Plain Information - Truckee River - Reno, Sparks - Truckee Meadows, Nevada, USCOE, Sacramento District, October 1970.

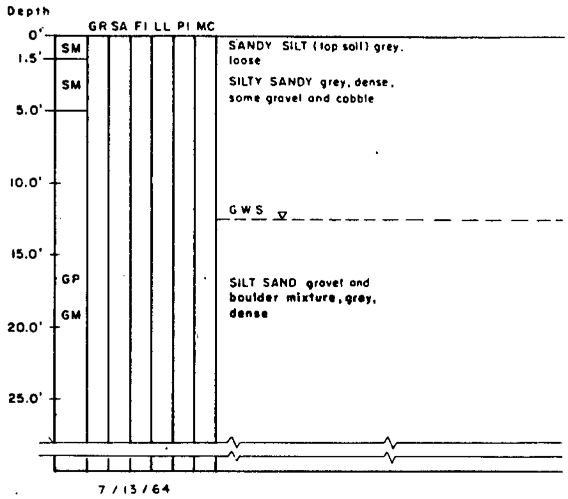
3. Watershed Sedimentation Investigation for the Truckee River Basin, Verdi to Vista. Special Projects Memo No. 82-4, July 1982, USCOE, HEC.

4. Soils and Geology Office Study - Truckee Meadows Investigation, USCOE, Sacramento District, September 1981.

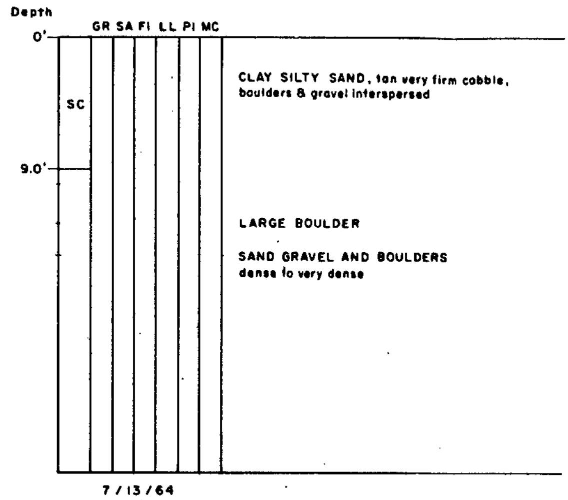
5. Geotechnical Exploration - Truckee Meadows Investigation Reno-Sparks Metropolitan Area, Nevada, Leeds, Hill, and Jewett, Inc., May 1982.

6. Plan for Channel Modifications - Truckee River - Twin Lakes Drive to U.S. Highway 395, Leeds, Hill, and Jewett, Inc., March 1982.

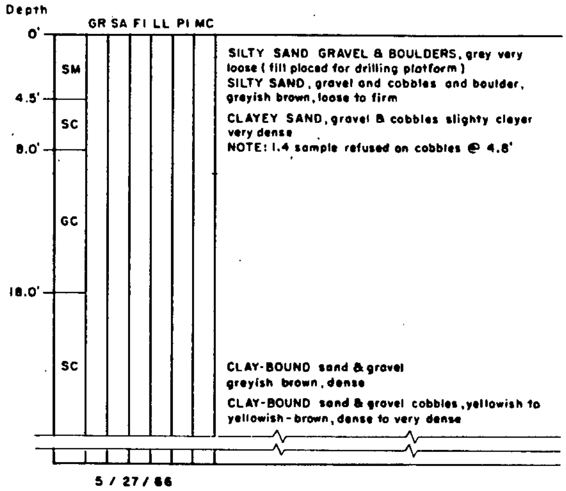
1


Depth
GR SA FI LL PI MC
0'
1.5'
5.0'
10.0'
15.0'
20.0'
25.0'
SM
SM
GP
GM
SANDY SILT (top soil) grey, loose
SILTY SANDY grey, dense, some gravel and cobble
GWS
SILT SAND gravel and boulder mixture, grey, dense
7 / 13 / 64

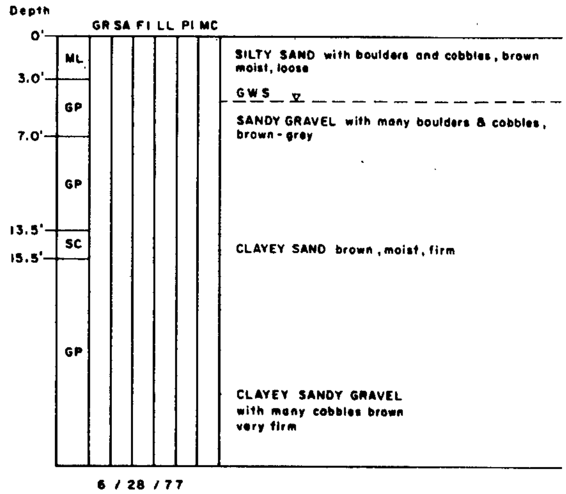
20


Depth
GR SA FI LL PI MC
0'
9.0'
SC
CLAY SILTY SAND, tan very firm cobble, boulders & gravel interspersed
LARGE BOULDER
SAND GRAVEL AND BOULDERS dense to very dense
7 / 13 / 64

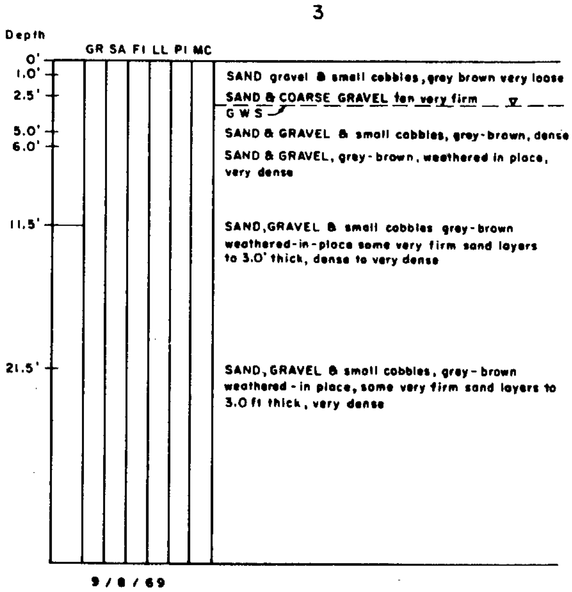
26


Depth
GR SA FI LL PI MC
0'
4.5'
8.0'
18.0'
SM
SC
GC
SC
SILTY SAND GRAVEL & BOULDERS, grey very loose (fill placed for drilling platform)
SILTY SAND, gravel and cobbles and boulder, greyish brown, loose to firm
CLAYEY SAND, gravel & cobbles slighty clayer very dense
NOTE: 1.4 sample refused on cobbles @ 4.8'
CLAY-BOUND sand & gravel greyish brown, dense
CLAY-BOUND sand & gravel cobbles, yellowish to yellowish-brown, dense to very dense
5 / 27 / 66

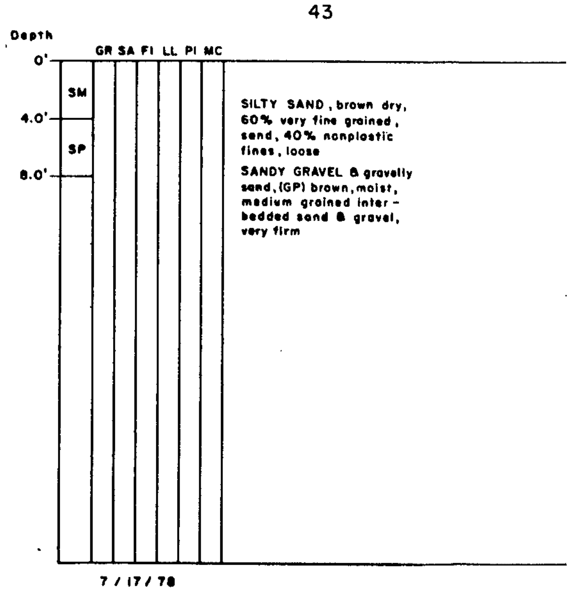
28


Depth
GR SA FI LL PI MC
0'
3.0'
7.0'
13.5'
15.5'
ML
GP
GP
SC
GP
SILTY SAND with boulders and cobbles, brown moist, loose
GWS
SANDY GRAVEL with many boulders & cobbles, brown-grey
CLAYEY SAND brown, moist, firm
CLAYEY SANDY GRAVEL with many cobbles brown very firm
6 / 28 / 77

3


Depth
GR SA FI LL PI MC
0'
1.0'
2.5'
5.0'
6.0'
11.5'
21.5'
SAND gravel & small cobbles, grey brown very loose
SAND & COARSE GRAVEL tan very firm
GWS
SAND & GRAVEL & small cobbles, grey-brown, dense
SAND & GRAVEL, grey-brown, weathered in place, very dense
SAND, GRAVEL & small cobbles grey-brown weathered-in-place some very firm sand layers to 3.0' thick, dense to very dense
SAND, GRAVEL & small cobbles, grey-brown weathered-in place, some very firm sand layers to 3.0 ft thick, very dense
9 / 8 / 69

43


Depth
GR SA FI LL PI MC
0'
4.0'
8.0'
SM
SP
SILTY SAND, brown dry, 60% very fine grained, sand, 40% nonplastic fines, loose
SANDY GRAVEL & gravelly sand, (GP) brown, moist, medium grained inter-bedded sand & gravel, very firm
7 / 17 / 78

20

Depth	Symbol	GR	SA	FI	LL	PI	MC	Description
0'	SC							CLAY SILTY SAND, tan very firm cobble, boulders & gravel interspersed
.0'								LARGE BOULDER
								SAND GRAVEL AND BOULDERS dense to very dense

7 / 13 / 64

22

Depth	Symbol	GR	SA	PI	LL	PI	MC	Description
0'	SM							SANDY GRAVEL, brown, dry, dense, some silty fines
5.0'	SC							SANDY GRAVEL, brownish grey, moist to wet numerous cobbles and occasional boulders to 18" diameter, little fines.
10.0'								
14.0'								

7 / 21 / 72

##

Depth	GR	SA	PI	LL	PI	MC	Description
0'							
1.0'							ASPHALT BASE GRAV GRAVEL or
11.0'							SILTY SAN
15.0							DRY, DENSE SANDY SIL

7 / 13 / 64

28

Depth	Symbol	GR	SA	FI	LL	PI	MC	Description
0'	ML							SILTY SAND with boulders and cobbles, brown moist, loose
								GWS ▽
	GP							SANDY GRAVEL with many boulders & cobbles, brown - grey
	GP							
	SC							CLAYEY SAND brown, moist, firm
	GP							CLAYEY SANDY GRAVEL with many cobbles brown very firm

6 / 28 / 77

31

Depth	Symbol	GR	SA	FI	LL	PI	MC	Description
0'	SP							SAND brown-grey, dry to moist, 95% fine-medium poorly graded sand inter-bedde with medium-coarse sand, 5% slightly plastic fine, firm
2.0'								
5.0'	GM							SANDY GRAVEL grey-brown dry - wet (tighter below groundwater surface) 65% gravel to 3 inch diameter, 35% medium - coarse sand (mostly coarse) 15-20% numerous cobbles to 12" diameter, 2-3% occasional boulder to 2" diameter, firm to very firm
10.0'								
15.0'								
20.0'								
25.0'								
30.0'								

1 / 29 / 79

43

Depth	Symbol	GR	SA	FI	LL	PI	MC	Description
	SM							SILTY SAND, brown dry, 60% very fine grained, sand, 40% nonplastic fines, loose
	SP							SANDY GRAVEL & gravelly sand, (GP) brown, moist, medium grained inter - bedded sand & gravel, very firm

7 / 17 / 78

44

Depth	Symbol	GR	SA	FI	LL	PI	MC	Description
0'	GM							SANDS & gravel with some cobbles, coarse sands & gravel, silty gravel, dense
15.0'	SM							
16.5'	GM							SANDS & GRAVEL with cobbles & boulders, dense
25.0'	CL							CLAY BOUND rock fragments, very hard
27.0'								CLEAN SAND & ROCK fragment
29.5'	GC							CLAY BOUND SAND & gravels very stiff
32.0'	GP							COMPACT, CLEAN SANDS clean, fine grained, very firm
36.0'	GC							SAND & GRAVEL clay - bound, very hard

2

UNIFIED SOIL CLA

MAJOR DIVISIONS			GROUP SYMBOLS
COARSE GRAINED SOILS	GRAVELS	Clean gravels	GW
			GP
		Gravels with fines	GM
			GC
	SANDS	Clean sands	SW
			SP
		Sands with fines	SM
			SC
FINE GRAINED SOILS	SILTS AND CLAYS	Liquid Limit below 50%	ML
			CL
			OL
		Liquid Limit 50% and above	MH
			CH
			OH
Highly organic soils			Pt

LEGEND:

- GR Gravel, percent by weight No. 4 sieve.
- SA Sands, percent by weight No. 200 sieve.
- FI Fines, percent by weight
- LL Liquid Limit.
- PI Plasticity Index (Liquid Li
- MC Field Moisture Content in
- Visual Field Classification
- Laboratory Classification

TRUCKEE MI
RENO-SPARKS ME

LOGS

SACRAMENTO DIST

0

22

SANDY GRAVEL, brown, dry, dense, some silty fines

SANDY GRAVEL, brownish grey, moist to wet numerous cobbles and occasional boulders to 18" diameter, little fines.

31

C

SAND brown-grey, dry to moist, 95% fine-medium poorly graded sand inter-bedde with medium-coarse sand, 5% slightly plastic fine, firm

SANDY GRAVEL grey-brown dry-wet (lighter below groundwater surface) 65% gravel to 3 inch diameter, 35% medium-coarse sand (mostly coarse) 15-20% numerous cobbles to 12" diameter, 2-3% occasional boulder to 2" diameter, firm to very firm

44

MC

SANDS & gravel with some cobbles, coarse sands & gravel, silty gravel, dense

SANDS & GRAVEL with cobbles & boulders, dense

CLAY BOUND rock fragments, very hard

CLEAN SAND & ROCK fragment

CLAY BOUND SAND & gravels very stiff

COMPACT, CLEAN SANDS clean, fine grained, very firm

SAND & GRAVEL clay-bound, very hard

11

Depth	GR	SA	PI	LL	PI	MC	
0'							ASPHALT
1.0'							BASE GRAVELS GRAVEL and cobbles and sandy-silty gravel interbeds dry, dense
11.0'							SILTY SAND, moist, very firm, occasional gravels
15.0							DRY, DENSE, SANDY-SILTY GRAVELS with occasional cobbles SANDY SILTY GRAVELS, dry, dense, occasional cobbles

7 / 13 / 64

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS	GRAVELS	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS	Liquid Limit below 50%	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts. Plasticity below "A" line.
			CL	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.
			OL	Organic silts and organic clays. Plasticity below "A" line.
		Liquid Limit 50% and above	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.
			CH	Inorganic fat clays. Plasticity above "A" line.
			OH	Organic clays or organic silts. Plasticity below "A" line.
Highly organic soils			Pt	Peat, organic content greater than 50%.

LEGEND:

GR	Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
SA	Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.
FI	Fines, percent by weight passing the No. 200 sieve.
LL	Liquid Limit.
PI	Plasticity Index (Liquid Limit Minus Plastic Limit).
MC	Field Moisture Content in Percent of Dry Weight.
*	Visual Field Classification.
#	Laboratory Classification of composite of all Samples Collected.

TRUCKEE MEADOWS INVESTIGATIONS
RENO-SPARKS METROPOLITAN AREA, NEVADA

LOGS OF BORINGS

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

PLATE 1

46

Depth	Class	GR	SA	FI	LL	PI	MC	Description
0'–2.0'	ML							SANDY SILT, brown, mist, 80% nonplastic fines 20% very fine to fine sand, soft to slightly stiff
2.0'–11.0'	SM							SILTY SAND, light brown, moist 30-40% nonplastic to low plastic fines, 60-70% very fine sand, loose to firm
11.0'–14.0'	GS							SILTY SAND or GRAVELLY SAND, grey, wet, 5-15% nonplastic fines, 70-80% very fine to coarse sand, 15% gravel to 1" across, very firm

1/16/69

50

Depth	Class	GR	SA	FI	LL	PI	MC	Description
0'–11.5'	SC SM							BROWN CLAYEY SILT, brown, wet, soft
								GWS ▽
11.5'–21.0'	SC							CLAYEY SILT, darkgreenish grey, wet very soft
21.0'–25.0'	SP							SAND, grey, wet, poorly graded sand, firm to dense
25.0'–	GP							SANDY. GRAVEL, dark grey saturated, little fines, dense to very dense

1/11/68

60

Depth	Class	GR	SA	FI	LL	PI	MC	Description
0'–6.0'	SM							SILTY SAND lightbrown dry medium dense — 6' FILL
6.0'–9.0'	ML							SANDY SILTY dark brown moist, with root holes, stiff
9.0'–28.5'	SM							SILTY SAND dark medium dense ▽ WATER LEVEL - 5/11/77 NOT STABILIZED; occasional lenses of sandy silt; numerous gravels at 23.0'
28.5'–	GP							SANDY GRAVEL grey-brown dense

5/11/77

62

Depth	Class	GR	SA	FI	LL	PI	MC	Description
0'–5.0'	SM							SILTY SAND brown moist, with roots loose to medium dense
5.0'–13.0'	SM							SILTY SAND brown moist medium dense with roots; ▽ WATER LEVEL - 5/11/77
13.0'–36.0'	SP							SAND, grey loose to medium dense; 20.0': (heaving sand experienced at 20.0') numerous gravel at 27.0' decreasing gravel content at 30'
36.0'–38.5'	SP							SANDY GRAVEL grey brown with cobbles, dense

5/11/77

70

Depth	(FC)	GR	SA	FI	LL	PI	MC	Description
0'–1.5'	CL							AUGER; SILTY CLAY dk. brown damp
1.5'–5.0'	CL							SANDY SILTY CLAY dk. brown moist low plasticity, 3 to 30% fine sand firm some organics (<10%) above depth of 3'
5.0'–10.5'	CL							30" Undisturbed push sample 2-7/8" I.D. Shelby tube, attempted 9" brown sandy silty clay, as above, recovered; 7.5': 36" Undisturbed push sample, 2-7/8" I.D. shelby tube
10.5'–14.5'	CH							CLAY, dk grey wet highly plastic, soft
14.5'–18.0'	SW							SILTY SAND, dark grey, sat fine to med grained sand firm approx. 20% silt, (15.5') 30" Undisturbed push sample 2-7/8" I.D. shelby tube
18.0'								NO RECOVERY

3/7/82

68

Depth	(FC)	GR	SA	FI	LL	PI	MC	Description
0'–1.5'								AUGER; SILTY SAND, brown damp
1.5'–3.0'	SM							SANDY SILTY CLAY brown damp some (<3% organics firm
3.0'–5.0'	CL SC SM							SANDY SILTY CLAY brown damp approx. 10% silt, 25% sand stiff clayey, silty sand, damp approx. fines firm
5.0'–7.0'	CL							SANDY SILTY CLAY brown moist, low plasticity approx. 20% fine sand & silt firm
7.0'–15.5'	SP							SILTY SAND brown, saturated fine to medium grained sand from 0 to <5% silt; SILTY SAND brown, saturated fine to med. grained sand from 0 to < 5% silt,
15.5'								NO RECOVERY

3/6/82

Depth 0' M 4.0' 5.0' C 13.0' S 15.0' 17.0' S 24.0' S

Depth 0' 15.0' 16.0' 17.0' 0' 27.5' 30.0'

Depth 0' 1.5' 3.0' 5.0' 6.0' 8.5' 10.0' 12.0' 13.0' 16.0' 17.0'

50

I LL PI MC

BROWN CLAYEY SILT, brown, wet, soft

GWS ▽

CLAYEY SILT, darkgreenish grey, wet very soft

SAND, grey, wet, poorly graded sand, firm to dense

SANDY. GRAVEL, dark grey saturated, little fines, dense to very dense

/68

55

Depth GR SA FI LL PI MC

0'
ML — SANDY SILT, grey, dry 85% slightly plastic fines, 15% very fine to fine sand, slightly stiff.
4.0'
5.0' — SILTY SAND, dry 35% nonplastic fine, 65% very fine to fine sand, fine 5'-13'
CL — SANDY CLAYEY SILT, moist 95% slightly plastic fines, 5% very fine sand, soft
13.0'
SC — CLAYEY SANDY SILT, moist 60% low plastic fines, 40% very fine to fine sand 15'-17', soft
15.0'
17.0'
SM — SILTY SAND, blue-grey wet 20% low plastic fines, 80% very fine to medium sand, firm 17'-24'
24.0'
SW — GRAVEL SAND, blue grey wet, 5% nonplastic fines, 60% fine to medium sand, 30' gravel to 1" diameter, dense

5/9/79

59

Depth GR SA FI LL PI MC

0'
ML — SANDY dry silt dark brown, d and dry moist stiff occasional
5.0' — LENS of silty sand 5' fill
SILT dark gray, soft to mediu orgnonic content

GWS (5/10/77) ▽ (NOT STABILIZED)

14.0'
SP — SAND, grey, saturated mediu

SANDY GRAVEL (GP) grey -brown dense
25.0'

5/9/77

62

FI LL PI MC

SILTY SAND brown moist, with roots loose to medium dense

SILTY SAND brown moist medium dense with roots

▽ WATER LEVEL - 5/11/77

SAND, grey loose to medium dense

(heaving sand experienced at 20.0') numerous gravel at 27.0' decreasing gravel content at 30'

SANDY GRAVEL grey brown with cobbles, dense

1/77

56

Depth GR SA FI LL PI MC

0'
ML — SILT dark grey-brown moist, medium stiff

▽ Water level - 5/10/77

15.0'
16.0'
17.0' — SILTY SAND dark grey, saturated lens of gravel at 16.0' to 17.0', medium dense
0'
SM
27.5'
GP — SANDY GRAVEL grey brown, dense
30.0'

5/10/77

66

Depth GR SA FI LL PI MC

0'
FC — AUGER, SILTY CLAYEY SAND,
1.0'
CL — SANDY SILTY CLAY dark-br brown, damp, low to medium pl
6.5'
CH — CLAY, dark gray, moist, mediu very soft
9.5' — AUGER, 36" Undisturbed pus shelby tube
12.5' — SILTY CLAY, dark grey moist approx. 10% silt, stiff
14.5' — SAND, dark grey, saturated f sand, very firm, very clean
SP

3/5/82

68

FI LL PI MC

AUGER; SILTY SAND, brown damp
SANDY SILTY CLAY brown damp some (<3% organics firm
SANDY SILTY CLAY brown damp approx. 10% silt, 25% sand stiff clayey, silty sand, damp approx. fines firm
SANDY SILTY CLAY brown moist, low plasticity approx. 20% fine sand & silt firm
SILTY SAND brown, saturated fine to medium grained sand from 0 to <5% silt
SILTY SAND brown, saturated fine to med. grained sand from 0 to < 5% silt,

NO RECOVERY

6/82

64

Depth (FC) GR SA FI LL PI MC

0'
SC — AUGER; SANDY CLAY dk. brown damp some roots
1.5'
SM/SP — SILTY SAND med. brown damp, non-plastic, approx. 10% silt some grass roots firm
3.0'
CL — SILTY CLAY, dk. gray damp, low plasticity, <5% firm to stiff
5.0'
6.0'
CL — SANDY SILTY CLAY dk. grey, damp to moist, med. plasticity, approx. 5% fine sand, 15% silt
8.5' — 30" Undisturbed push sample 2-7/8" I.D. shelby tube
10.0' — AUGER
CH — SANDY SILTY CLAY grey to greenish-grey wet high plasticity, <3% fine sand, soft
12.0'
13.0' — CLAYEY SAND, grey, saturated fine to med. grained sand, firm non-plastic
CH — CLAY sat high plasticity firm
16.0'
17.0' — SANDY CLAY dk. grey, sat, mdd. to low plasticity firm
SP — CLAYEY SILTY sand sat some (<10%) organics,

SANDY, greyish-brown, sat med to coarse gained sand approx 10% coarse sand firm

3/4/82

TRUCKEE MEADOWS
RENO-SPARKS METROPOL

LOGS OF

SACRAMENTO DISTRICT, C
OCTOBER

2

55

ILT, grey, dry 85% slightly plastic fines,
/ fine to fine sand, slightly stiff.
AND, dry 35%
ic fine, 65% very
ine sand, fine 5'-13'
CLAYEY SILT, moist
ghtly plastic fines,
fine sand, soft
SANDY SILT, moist
plastic fines,
ry fine to fine
-17', soft
ND, blue-grey
low plastic fines,
ry fine to medium
m 17'-24'
SAND, blue grey wet, 5% nonplastic
)% fine to medium sand, 30' gravel
imeter, dense

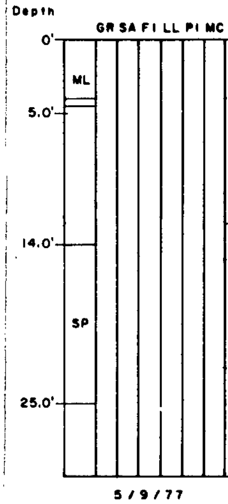
56

k grey-brown moist, medium stiff
evel - 5/10/77
AND dark grey, saturated lens of gravel
o 17.0', medium dense
RAVEL grey brown, dense

64

SANDY CLAY dk. brown damp some roots
AND med. brown damp, non-plastic,
10% silt some grass roots firm
LAY, dk. grey damp, low plasticity, <5%
stiff
SILTY CLAY dk. grey, damp to moist, med.
ty, approx. 5% fine sand, 15% silt
isturbed push sample 2-7/8" I.D. shelby tube
SILTY CLAY grey to greenish-grey wet high
ty, <3% fine sand, soft
SAND, grey, saturated fine to med. grained
m non-plastic
of high plasticity firm
CLAY dk. grey, sat, med. to low plasticity
SILTY sand sat some (<10%) organics,
greyish-brown, sat med to coarse gained
prox 10% coarse sand firm

59



SANDY dry silt dark brown, dry to moist with roots and dry moist stiff occasional gravel becoming moist

LENS of silty sand 5' fill

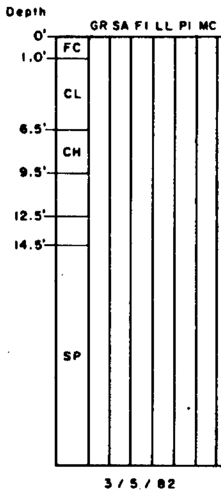
SILT dark gray, soft to medium stiff, wet with high orgnanic content

GWS (5/10/77) ▽
(NOT STABILIZED)

SAND, grey, saturated medium dense

SANDY GRAVEL (GP) grey -brown dense

66



AUGER, SILTY CLAYEY SAND, dark brown, moist

SANDY SILTY CLAY dark-brownish-grey or greyish-brown, damp, low to medium plasticity stiff

CLAY, dark gray, moist, medium to high plasticity very soft

AUGER, 36" Undisturbed push sample, 2-7/8" I.D. shelby tube

SILTY CLAY, dark grey moist, medium plasticity approx. 10% silt, stiff

SAND, dark grey, saturated fine to medium grained sand, very firm, very clean

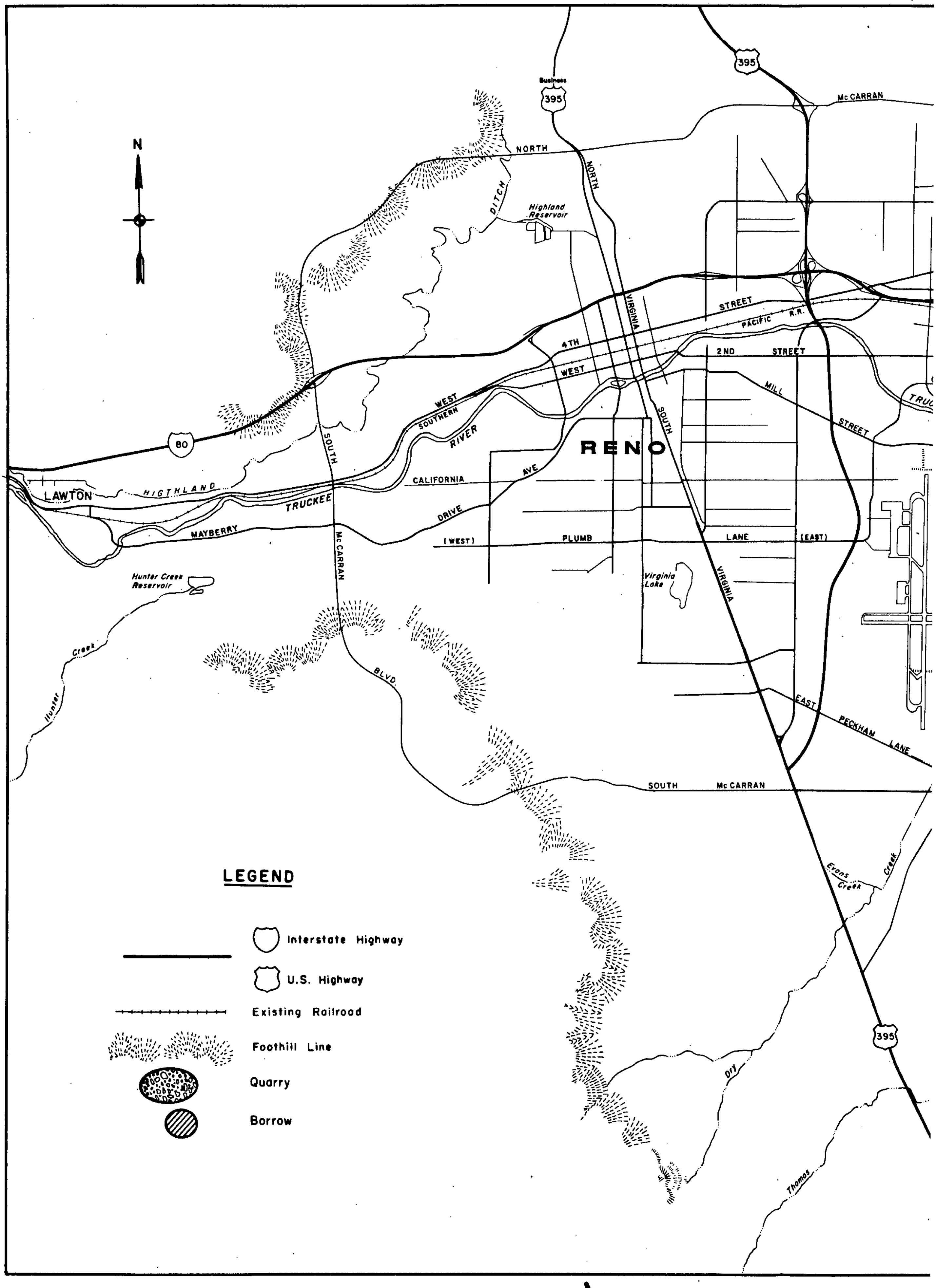
TRUCKEE MEADOWS INVESTIGATIONS
RENO-SPARKS METROPOLITAN AREA, NEVADA

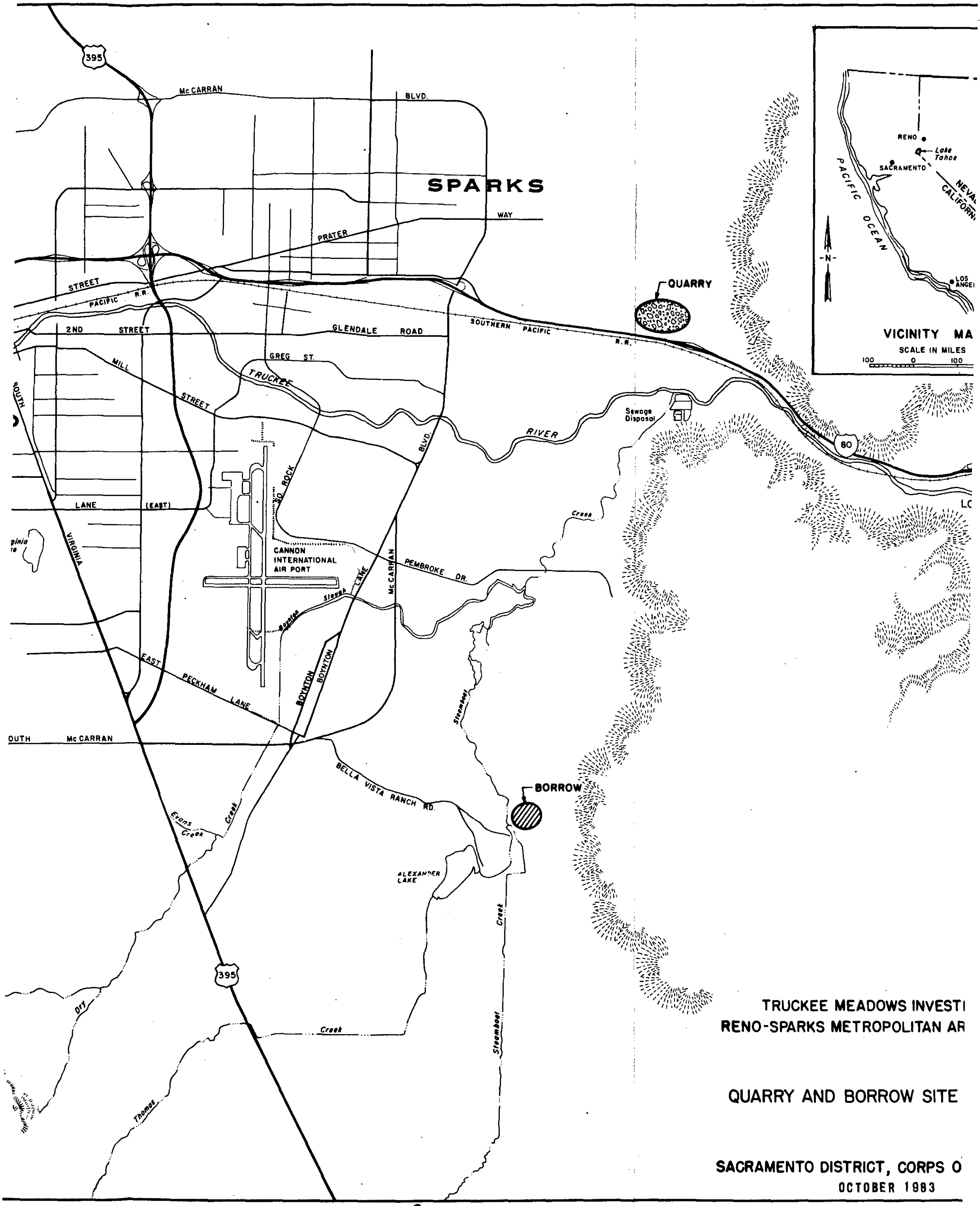
LOGS OF BORINGS

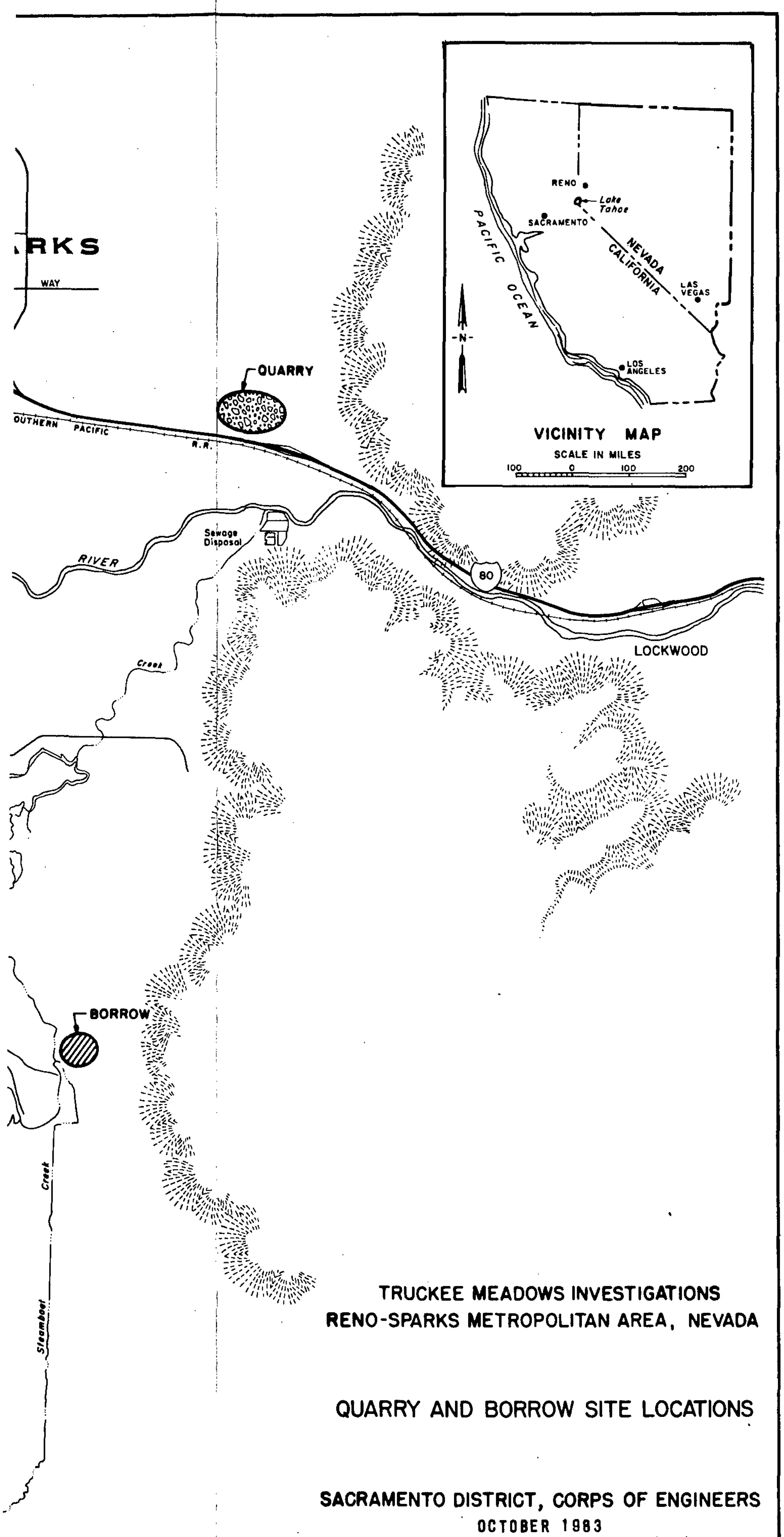
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

3

PLATE 2


N
Business
395
395
McCARRAN
NORTH
NORTH
DITCH
Highland Reservoir
VIRGINIA
STREET
PACIFIC R.R.
4TH
2ND STREET
WEST
WEST
SOUTHERN
MILL
STREET
TRUC
RIVER
SOUTH
SOUTH
RENO
80
LAWTON
HIGHLAND
TRUCKEE
CALIFORNIA
AVE
MAYBERRY
DRIVE
(WEST) PLUMB LANE (EAST)
McCARRAN
Hunter Creek Reservoir
Virginia Lake
VIRGINIA
Creek
Hunter
BLVD
EAST PECKHAM LANE
SOUTH McCARRAN
Evans Creek
Creek
395
Dry
Thomas
LEGEND
Interstate Highway
U.S. Highway
Existing Railroad
Foothill Line
Quarry
Borrow

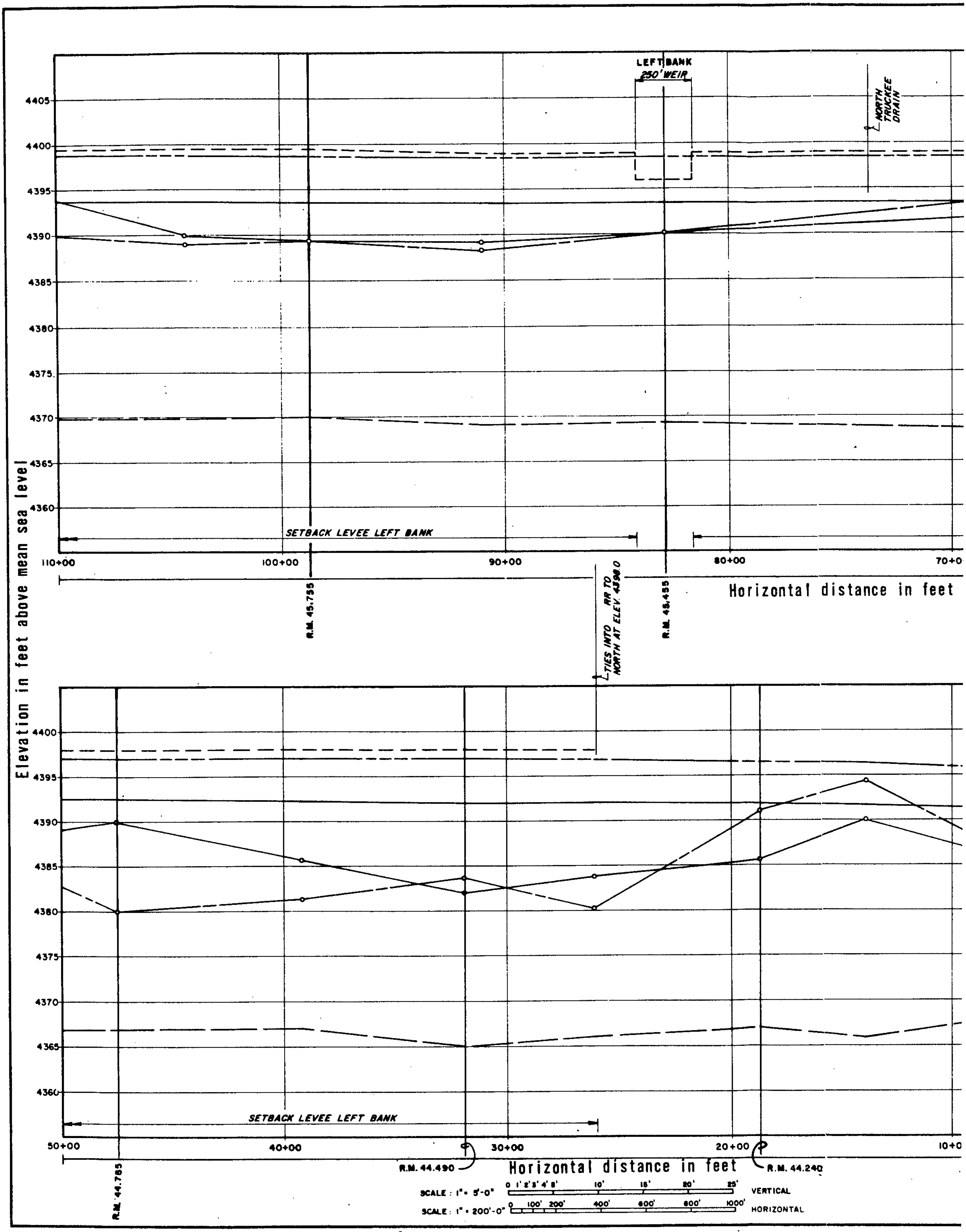

SPARKS
McCARRAN BLVD.
PRATER WAY
STREET
SOUTHERN PACIFIC R.R.
2ND STREET
GLENDALE ROAD
GREG ST.
MILL STREET
TRUCKEE RIVER
Sewage Disposal
QUARRY
BORROW
80
395
SOUTH VIRGINIA
LANE (EAST)
CANNON INTERNATIONAL AIR PORT
PEMBROKE DR.
EAST PECKHAM LANE
BOYNTON
BOYNTON LANE
Boynton Slough
McCARRAN
SOUTH McCARRAN
BELLA VISTA RANCH RD.
Evans Creek
Creek
Steamboat Creek
ALEXANDER LAKE
Dry Creek
Thomas
VICINITY MA
SCALE IN MILES
100 0 100
RENO
Lake Tahoe
SACRAMENTO
PACIFIC OCEAN
NEVA
CALIFORN
LOS ANGE
N
TRUCKEE MEADOWS INVESTI
RENO-SPARKS METROPOLITAN AR
QUARRY AND BORROW SITE
SACRAMENTO DISTRICT, CORPS O
OCTOBER 1983



TRUCKEE MEADOWS INVESTIGATIONS
RENO-SPARKS METROPOLITAN AREA, NEVADA

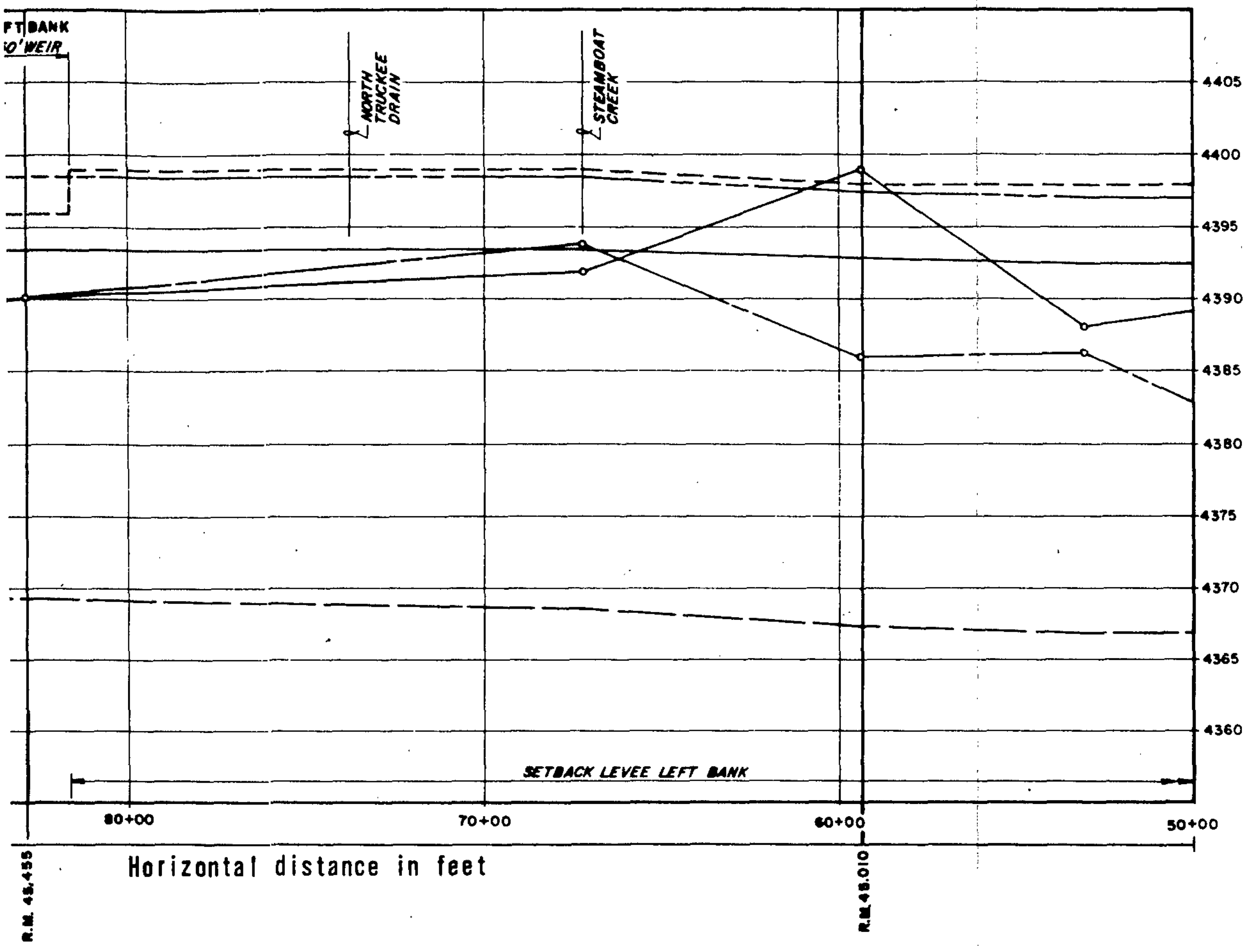
QUARRY AND BORROW SITE LOCATIONS

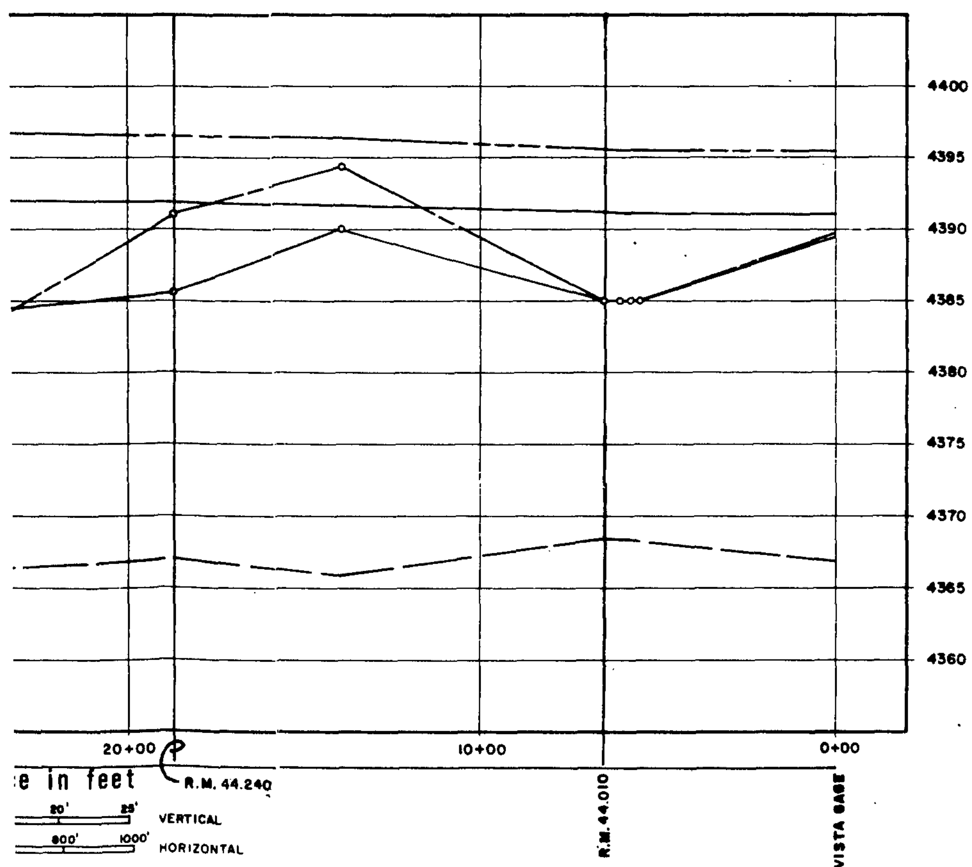
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983



LEFT BANK
250' WEIR
NORTH TRUCKEE DRAIN
SETBACK LEVEE LEFT BANK
110+00
100+00
90+00
80+00
70+00
R.M. 45.755
TIES INTO RR TO NORTH AT ELEV. 4398.0
R.M. 45.455
Horizontal distance in feet
Elevation in feet above mean sea level
SETBACK LEVEE LEFT BANK
50+00
40+00
30+00
20+00
10+00
R.M. 44.785
R.M. 44.490
R.M. 44.240
Horizontal distance in feet
SCALE : 1" = 5'-0"
VERTICAL
SCALE : 1" = 200'-0"
HORIZONTAL

1





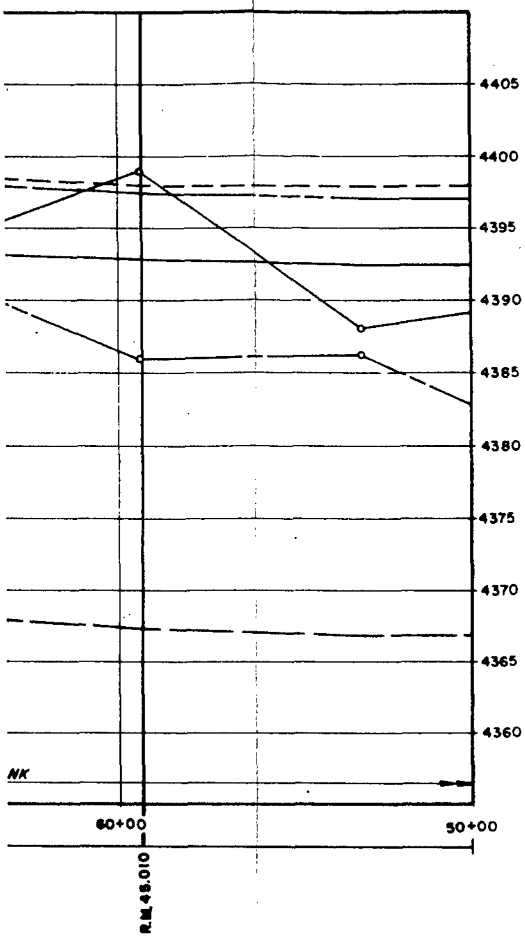
LEGEND

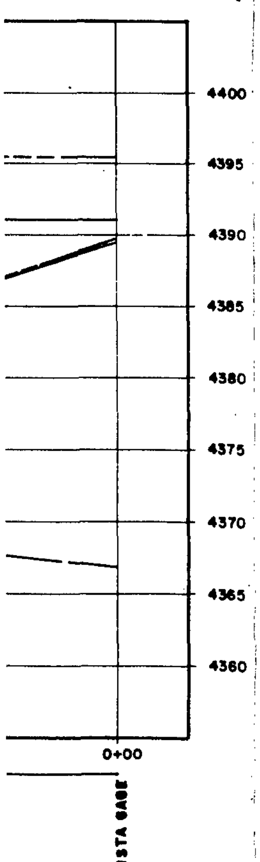
- 100 YEAR FLOOD
- STANDARD PROJECT FLOOD
- EXISTING LEFT BANK
- EXISTING RIGHT BANK
- CHANNEL INVERT
- IMPROVEMENTS/LEFT BANK
- IMPROVEMENTS/RIGHT BANK
- IMPROVEMENTS/LEFT & RIGH
- 44.010 – RIVER MILE (R.M. BEGINS AT P LAKE)

TRUCKEE MEADOWS INVESTIGAT
RENO-SPARKS METROPOLITAN AREA

TRUCKEE RIVER
PROFILE
STA. 0+00 to STA. 110+0C

SACRAMENTO DISTRICT, CORPS OF EN
OCTOBER 1983





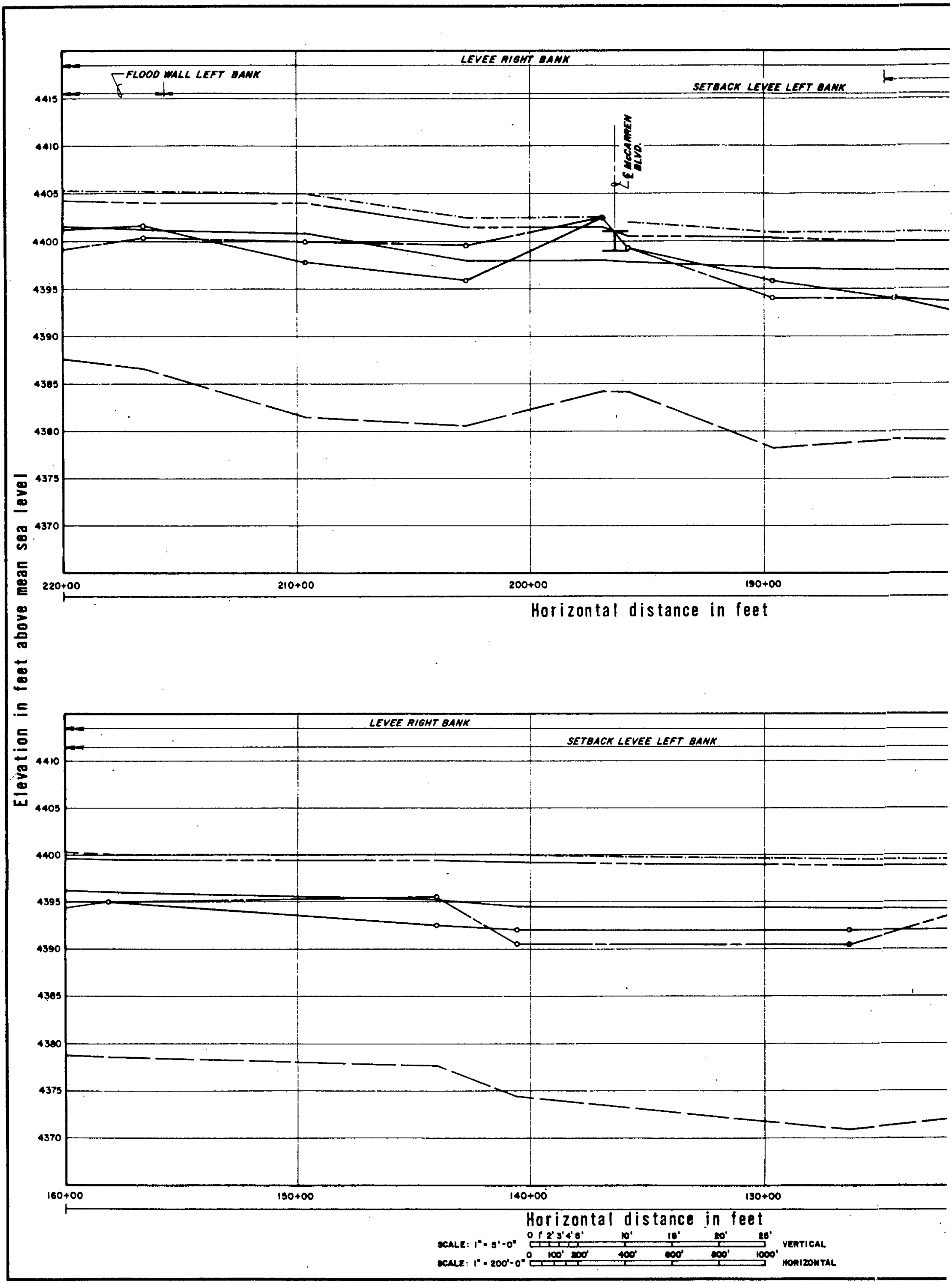
LEGEND

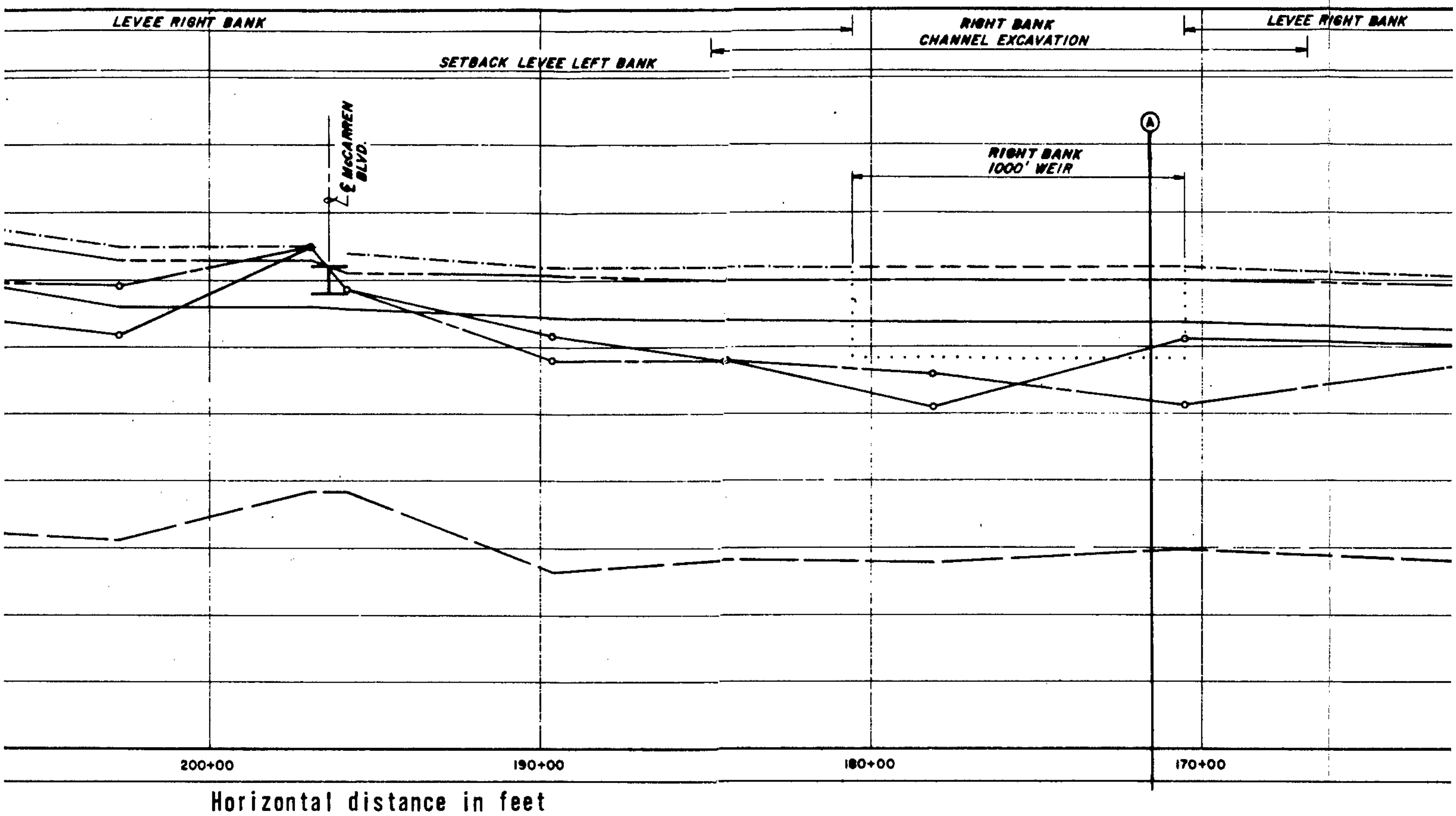
—	100 YEAR FLOOD
—	STANDARD PROJECT FLOOD
—	EXISTING LEFT BANK
—	EXISTING RIGHT BANK
—	CHANNEL INVERT
—	IMPROVEMENTS/LEFT BANK
—	IMPROVEMENTS/RIGHT BANK
—	IMPROVEMENTS/LEFT & RIGHT BANKS
44.010 —	RIVER MILE (R.M. BEGINS AT PYRAMID LAKE)

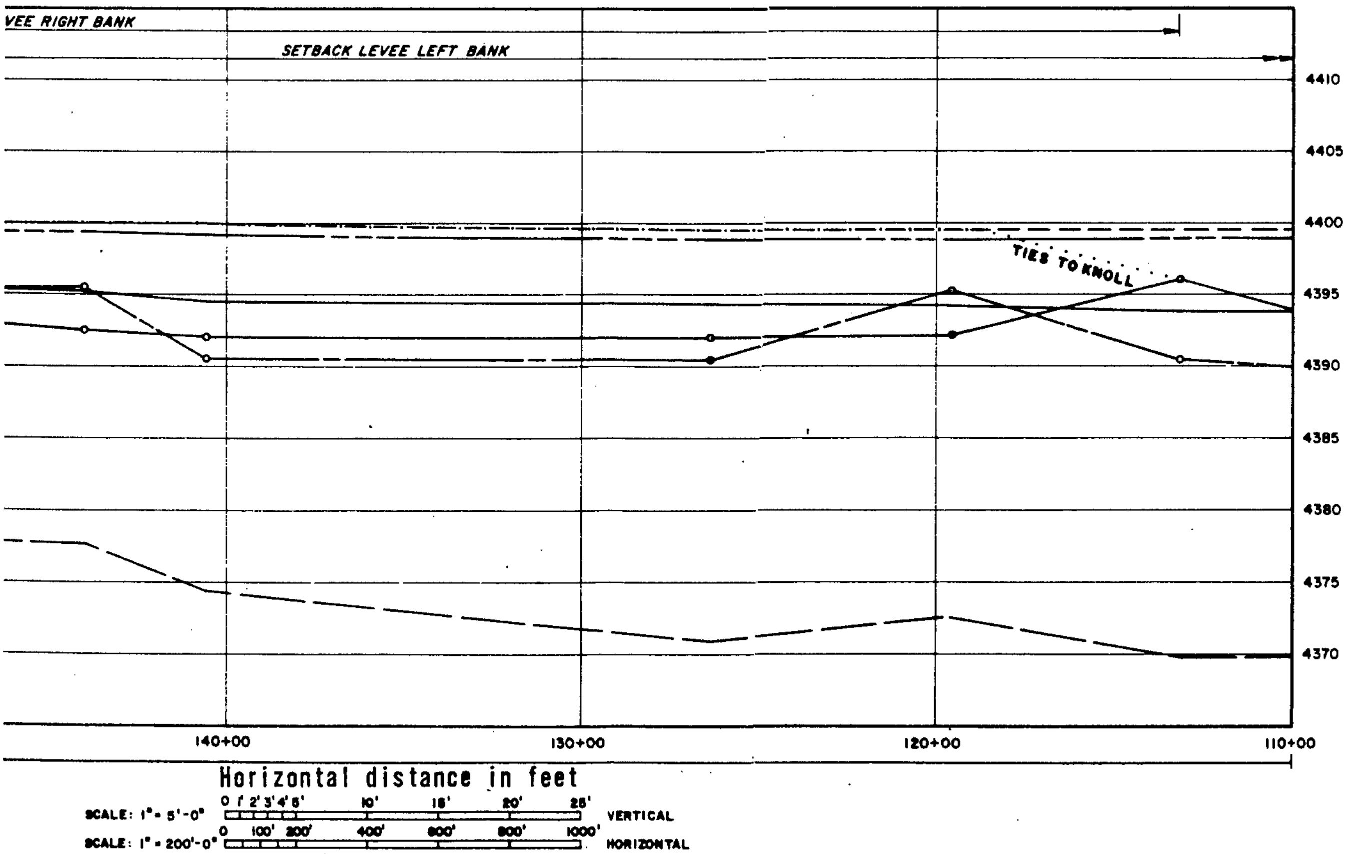
TRUCKEE MEADOWS INVESTIGATION
RENO-SPARKS METROPOLITAN AREA, NEVADA

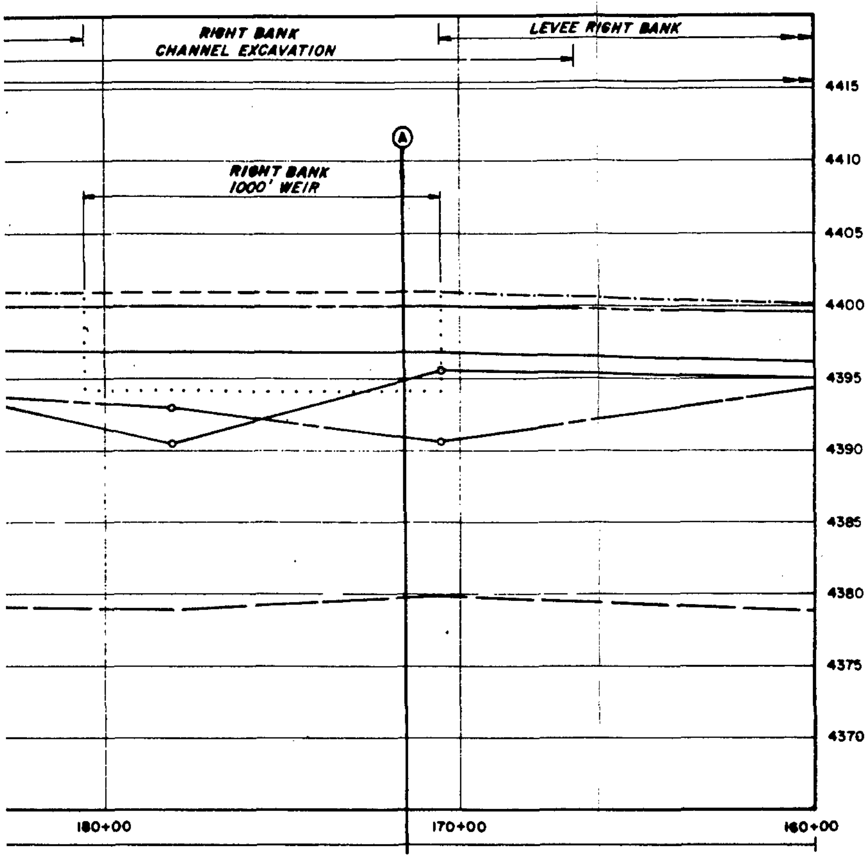
TRUCKEE RIVER
PROFILE
STA. 0+00 to STA. 110+00

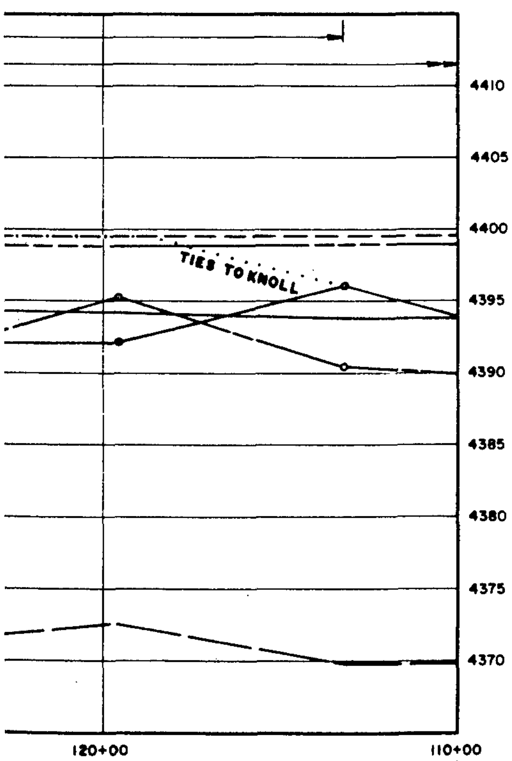
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

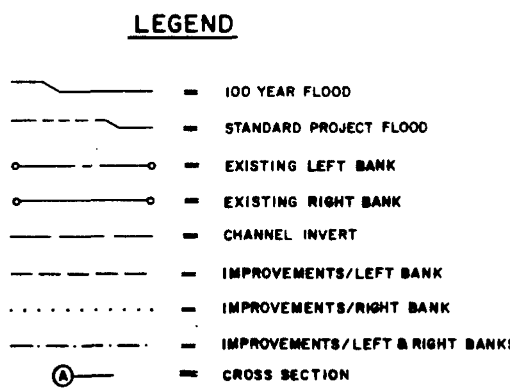

LEVEE RIGHT BANK
FLOOD WALL LEFT BANK
SETBACK LEVEE LEFT BANK
℄ McCARREN BLVD.
4415
4410
4405
4400
4395
4390
4385
4380
4375
4370
220+00
210+00
200+00
190+00
Horizontal distance in feet
Elevation in feet above mean sea level
LEVEE RIGHT BANK
SETBACK LEVEE LEFT BANK
4410
4405
4400
4395
4390
4385
4380
4375
4370
160+00
150+00
140+00
130+00
Horizontal distance in feet
SCALE: 1" = 5'-0"
0 1' 2' 3' 4' 5'
10'
15'
20'
25'
VERTICAL
SCALE: 1" = 200'-0"
0 100' 200'
400'
600'
800'
1000'
HORIZONTAL


LEVEE RIGHT BANK
SETBACK LEVEE LEFT BANK
RIGHT BANK
CHANNEL EXCAVATION
LEVEE RIGHT BANK
℄ McCARREN BLVD.
RIGHT BANK
1000' WEIR
A
200+00
190+00
180+00
170+00
Horizontal distance in feet


VEE RIGHT BANK
SETBACK LEVEE LEFT BANK
TIES TO KNOLL
4410
4405
4400
4395
4390
4385
4380
4375
4370
140+00
130+00
120+00
110+00
Horizontal distance in feet
SCALE: 1" = 5'-0"
0 1' 2' 3' 4' 5'
10'
15'
20'
25'
VERTICAL
SCALE: 1" = 200'-0"
0
100'
200'
400'
600'
800'
1000'
HORIZONTAL



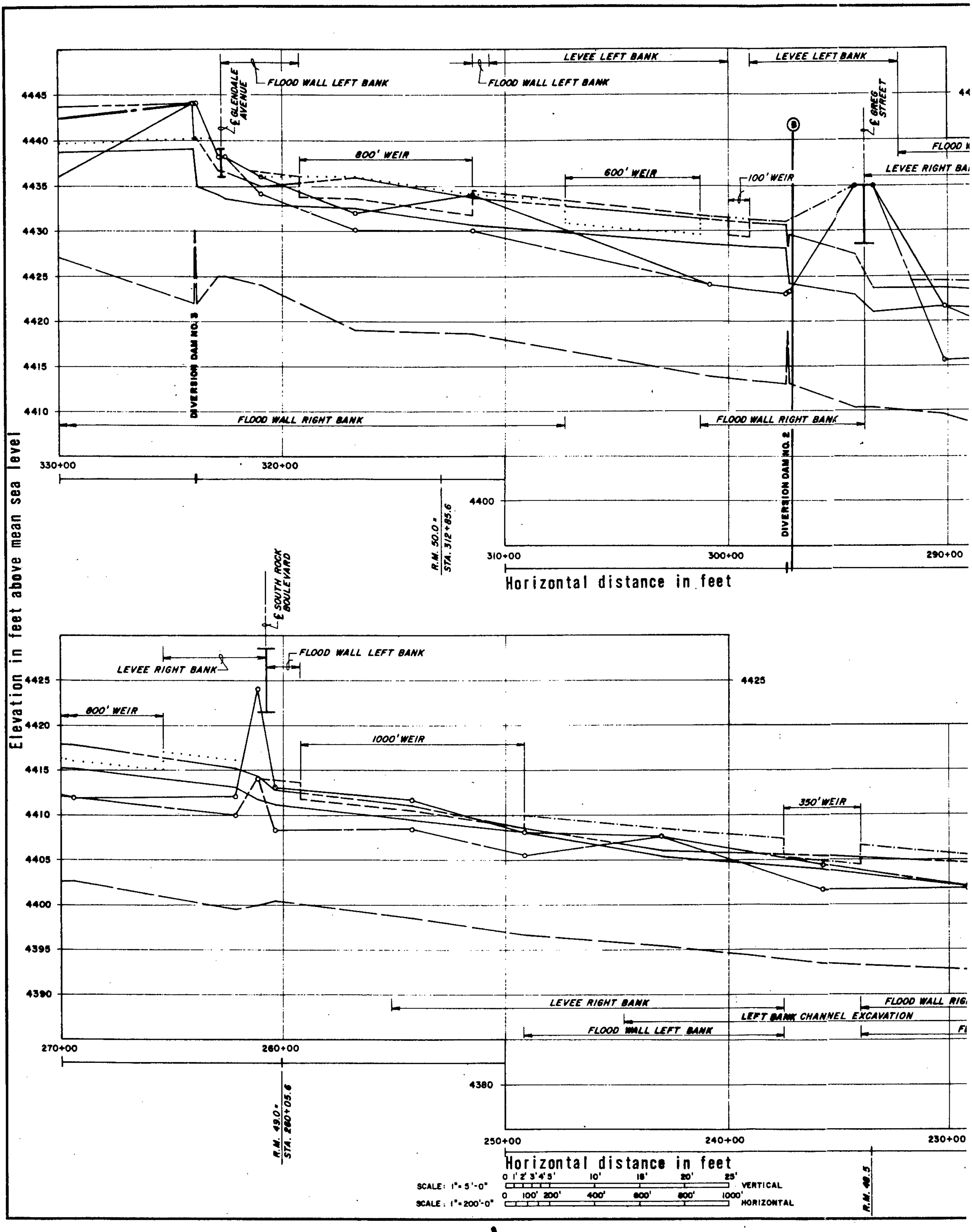


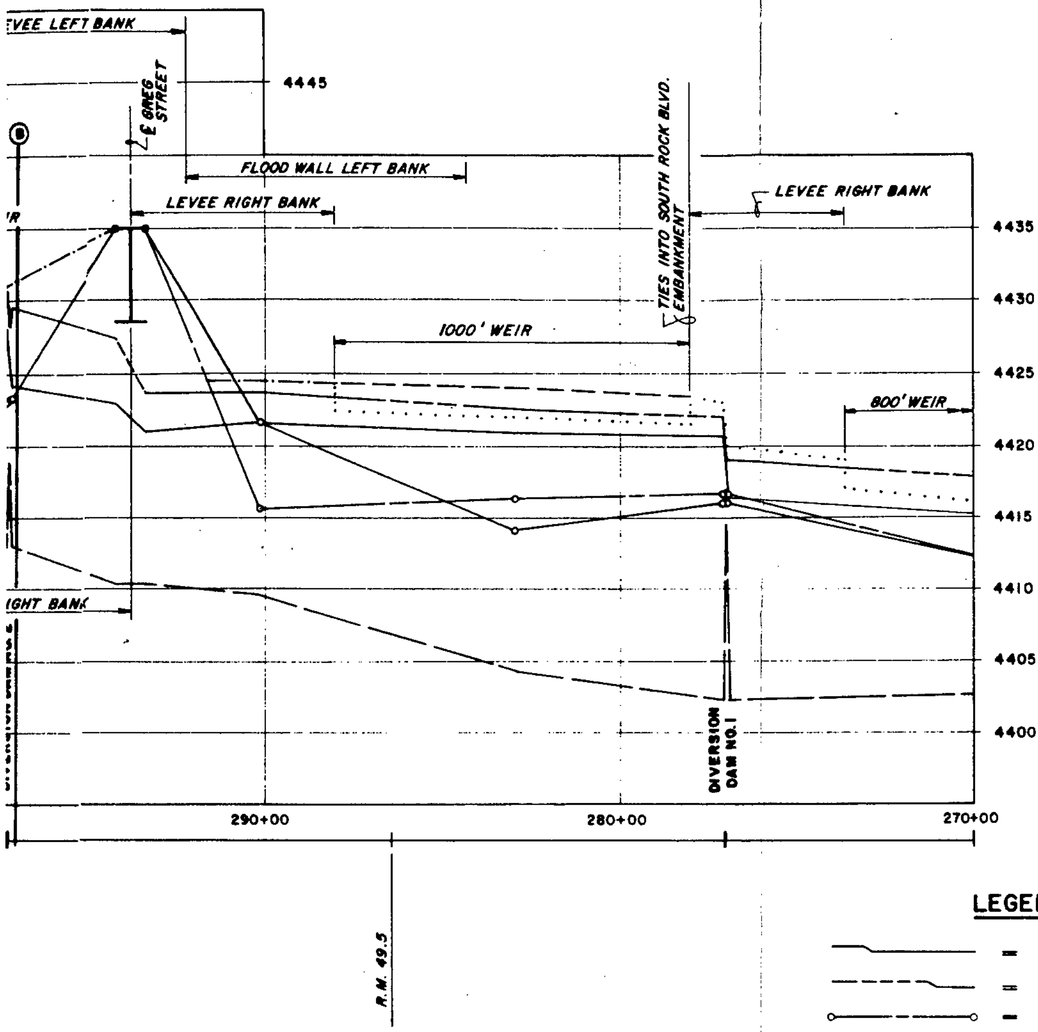


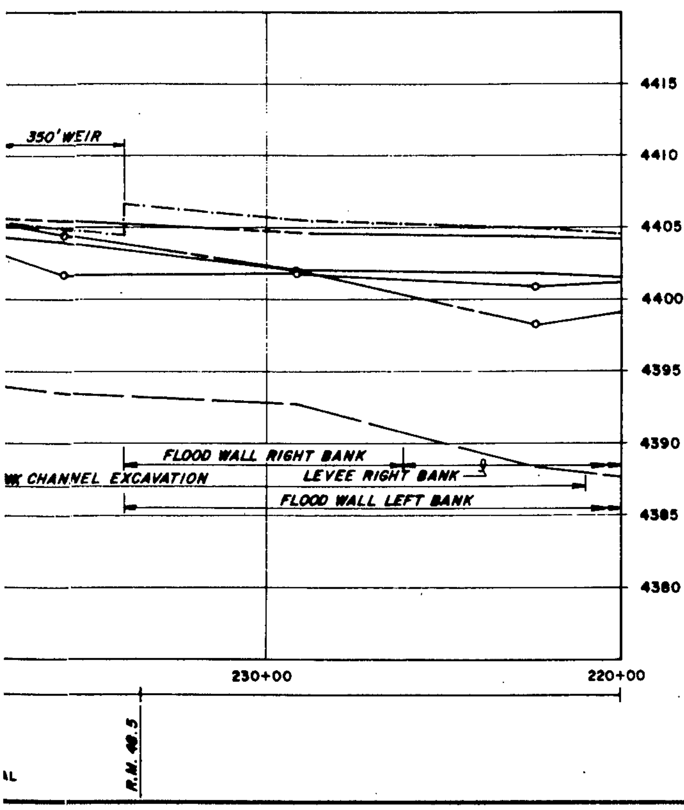
TRUCKEE MEADOWS INVESTIGATION
RENO-SPARKS METROPOLITAN AREA, NEVADA

TRUCKEE RIVER
PROFILE
STA. 110+00 to STA. 220+00

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983


Elevation in feet above mean sea level
LEVEE LEFT BANK
LEVEE LEFT BANK
FLOOD WALL LEFT BANK
FLOOD WALL LEFT BANK
℄ GLENDALE AVENUE
℄ GREG STREET
FLOOD W
LEVEE RIGHT BA
800' WEIR
600' WEIR
100' WEIR
DIVERSION DAM NO. 3
DIVERSION DAM NO. 2
FLOOD WALL RIGHT BANK
FLOOD WALL RIGHT BANK
4445
4440
4435
4430
4425
4420
4415
4410
4400
330+00
320+00
310+00
300+00
290+00
R.M. 50.0 = STA. 312+85.6
Horizontal distance in feet
℄ SOUTH ROCK BOULEVARD
LEVEE RIGHT BANK
FLOOD WALL LEFT BANK
800' WEIR
1000' WEIR
350' WEIR
LEVEE RIGHT BANK
LEFT BANK CHANNEL EXCAVATION
FLOOD WALL LEFT BANK
FLOOD WALL RIG
4425
4420
4415
4410
4405
4400
4395
4390
4380
270+00
260+00
250+00
240+00
230+00
R.M. 49.0 = STA. 260+05.6
R.M. 48.5
Horizontal distance in feet
SCALE: 1" = 5'-0"
0 1' 2' 3' 4' 5' 10' 15' 20' 25' VERTICAL
SCALE: 1" = 200'-0"
0 100' 200' 400' 600' 800' 1000' HORIZONTAL





LEGEND

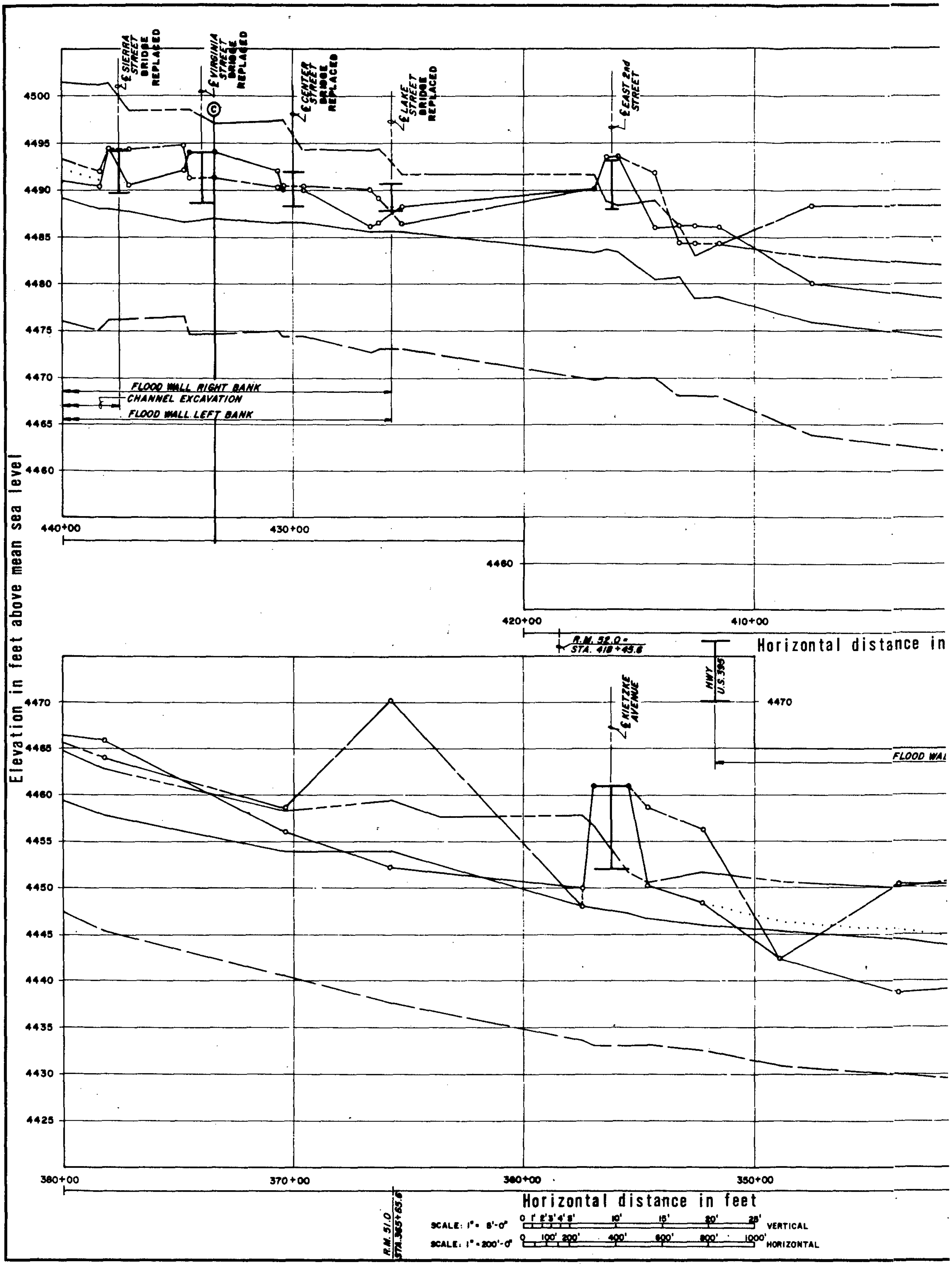
= 100 YEAR FLOOD
= STANDARD PROJECT FLOOD
= EXISTING LEFT BANK
= EXISTING RIGHT BANK
= CHANNEL INVERT
= IMPROVEMENTS/LEFT BANK
= IMPROVEMENTS/RIGHT BANK
= IMPROVEMENTS/LEFT & RIGHT BANK
= CROSS SECTION

TRUCKEE MEADOWS INVESTIGATION
RENO-SPARKS METROPOLITAN AREA, NEVADA

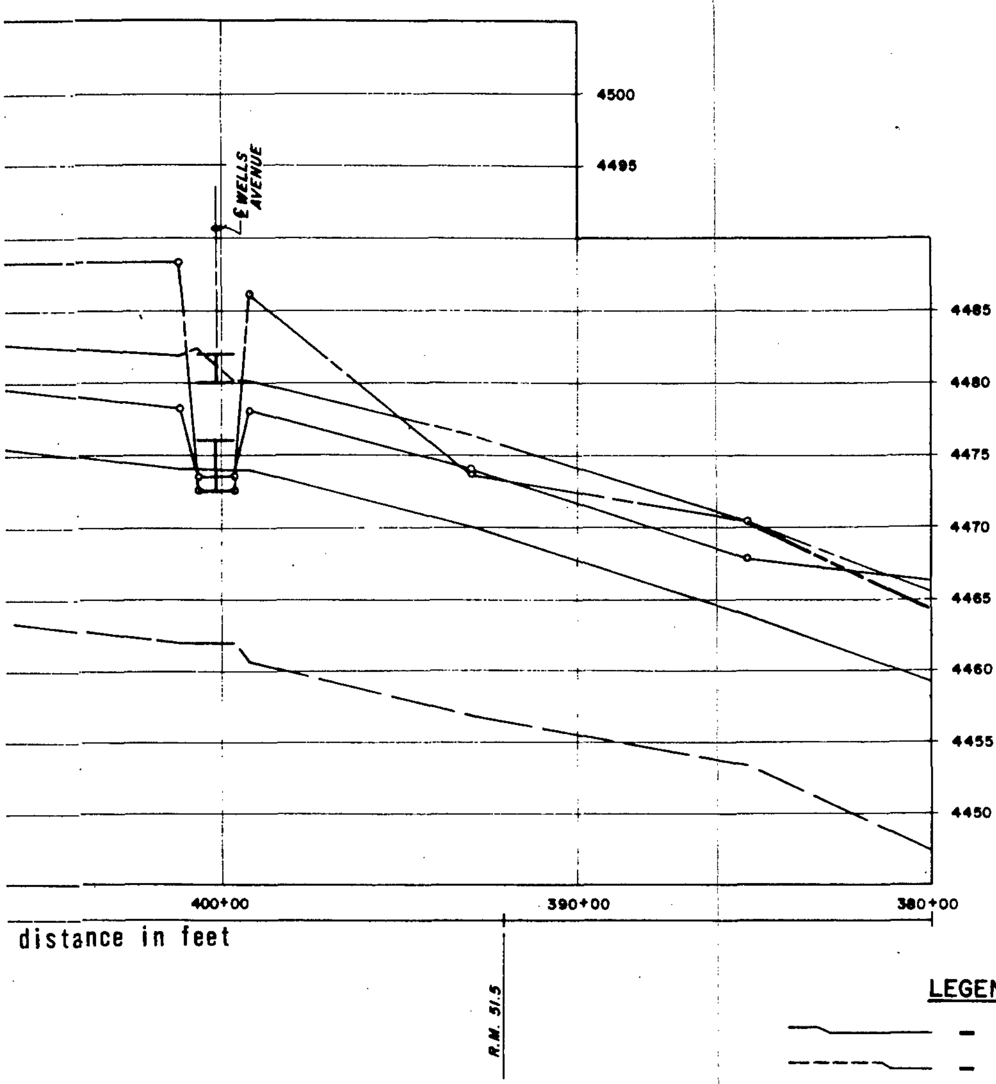
TRUCKEE RIVER
PROFILE
STA. 220+00 to STA. 330+00

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

PLATE 6

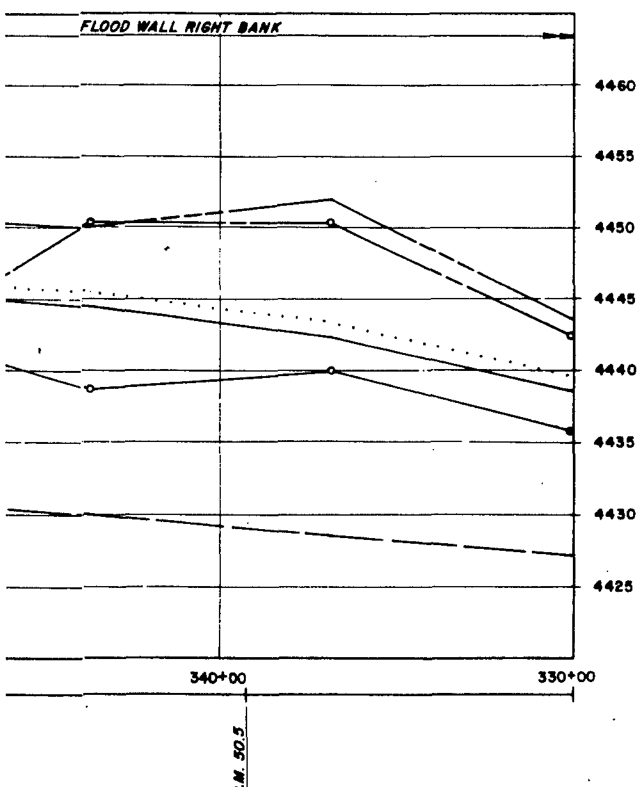


℄ SIERRA STREET BRIDGE REPLACED
℄ VIRGINIA STREET BRIDGE REPLACED
℄ CENTER STREET BRIDGE REPLACED
℄ LAKE STREET BRIDGE REPLACED
℄ EAST 2nd STREET
FLOOD WALL RIGHT BANK
CHANNEL EXCAVATION
FLOOD WALL LEFT BANK
Elevation in feet above mean sea level
4500
4495
4490
4485
4480
4475
4470
4465
4460
440+00
430+00
420+00
410+00
R.M. 52.0 = STA. 418+45.6
HWY U.S. 395
Horizontal distance in
℄ KIETZKE AVENUE
FLOOD WAL
4455
4450
4445
4440
4435
4430
4425
380+00
370+00
360+00
350+00
R.M. 51.0 / STA. 365+65.6
Horizontal distance in feet
SCALE: 1" = 5'-0"
0 1' 2' 3' 4' 5' 10' 15' 20' 25' VERTICAL
SCALE: 1" = 200'-0"
0 100' 200' 400' 600' 800' 1000' HORIZONTAL



LEGEND

100 YEAR FLOOD
STANDARD PROJECT FLOOD
EXISTING LEFT BANK
EXISTING RIGHT BANK
CHANNEL INVERT
IMPROVEMENTS/LEFT BANK
IMPROVEMENTS/RIGHT BANK
IMPROVEMENTS/LEFT & RIGHT BANKS
© = CROSS SECTION



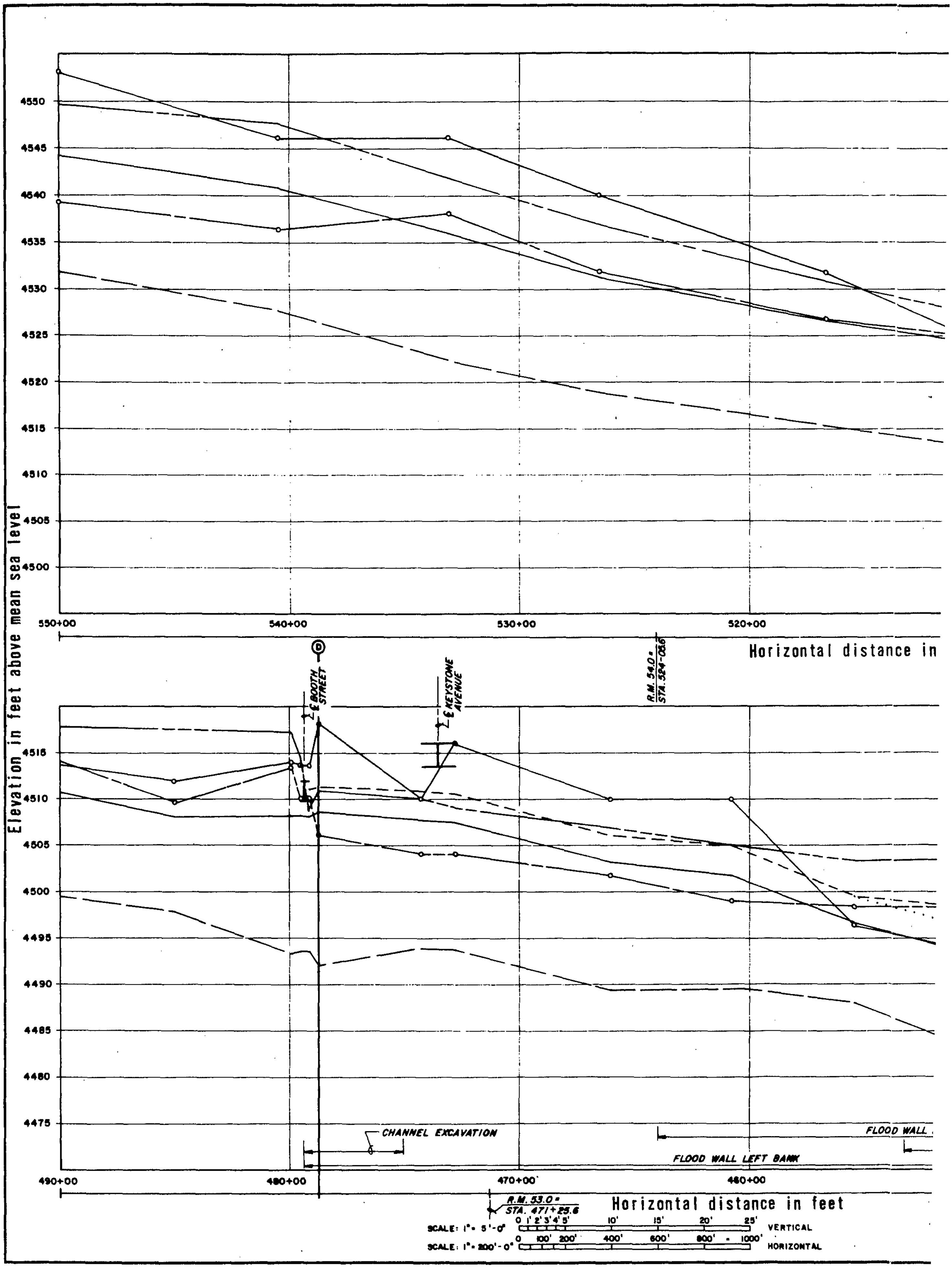
TRUCKEE MEADOWS INVESTIGATION
RENO-SPARKS METROPOLITAN AREA, NEVADA

TRUCKEE RIVER
PROFILE
STA. 330+00 to STA. 440+00

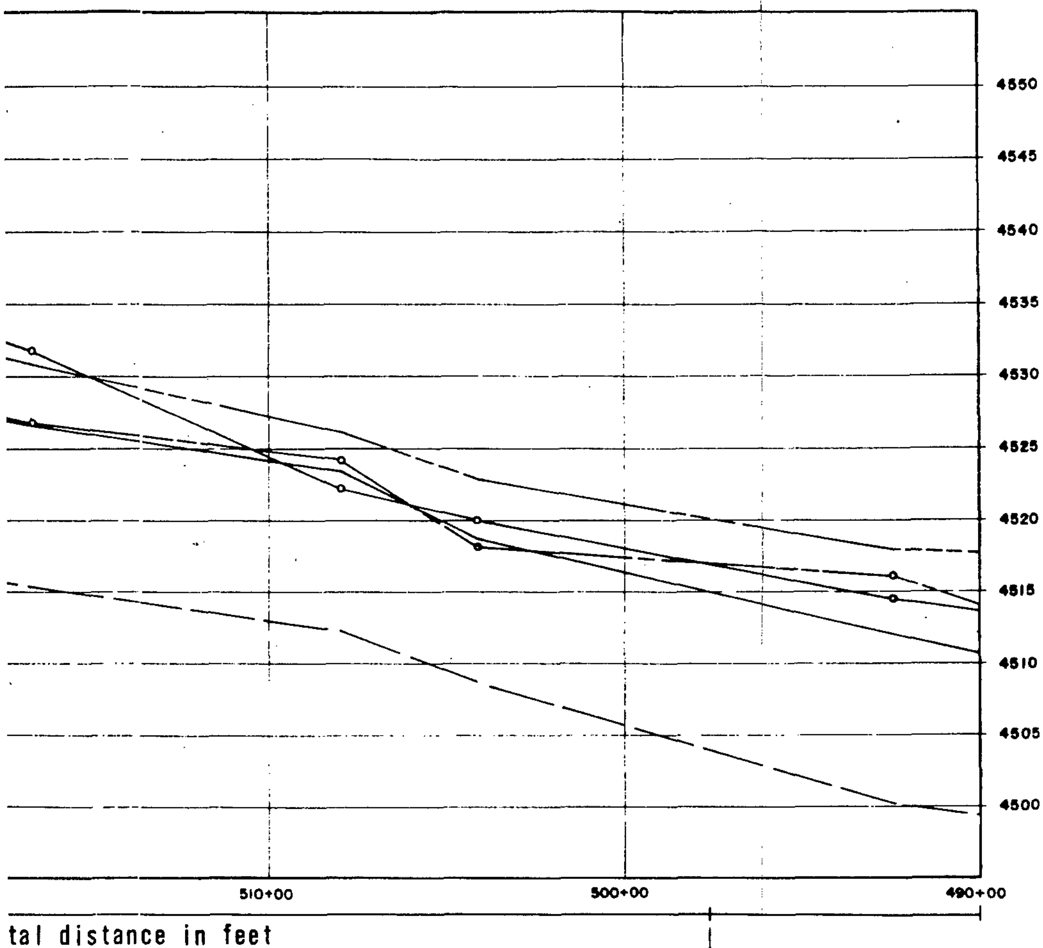
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

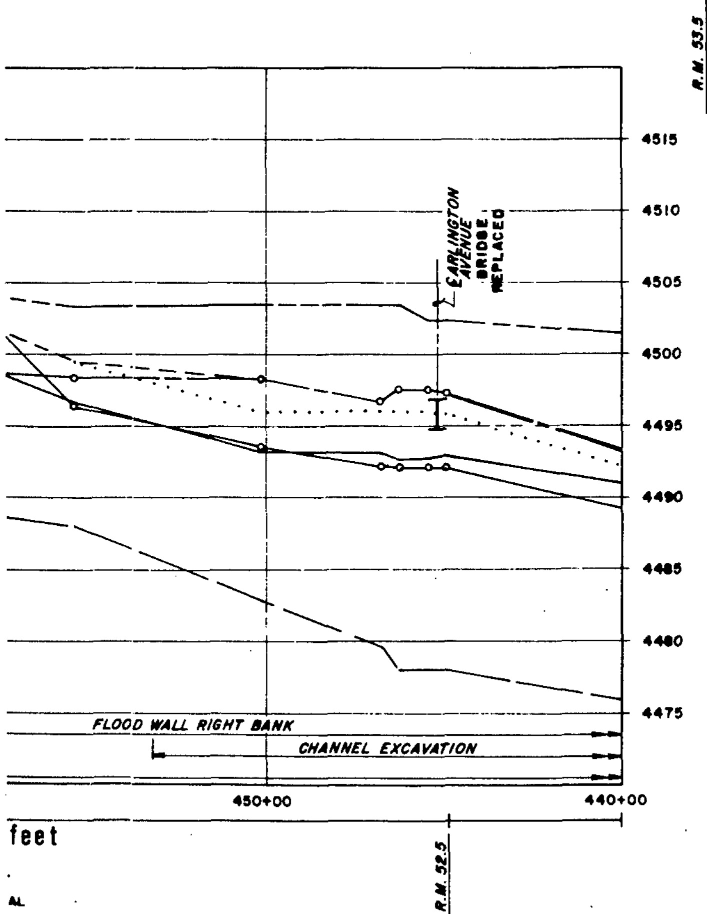
2

PLATE 7



Elevation in feet above mean sea level
4550
4545
4540
4535
4530
4525
4520
4515
4510
4505
4500
550+00
540+00
530+00
520+00
Horizontal distance in
D
℄ BOOTH STREET
℄ KEYSTONE AVENUE
R.M. 54.0 = STA. 524+08.6
4515
4510
4505
4500
4495
4490
4485
4480
4475
CHANNEL EXCAVATION
FLOOD WALL
FLOOD WALL LEFT BANK
490+00
480+00
470+00
460+00
R.M. 53.0 = STA. 471+25.6
Horizontal distance in feet
SCALE: 1" = 5'-0"
0 1' 2' 3' 4' 5' 10' 15' 20' 25'
VERTICAL
SCALE: 1" = 200'-0"
0 100' 200' 400' 600' 800' 1000'
HORIZONTAL





LEGEND

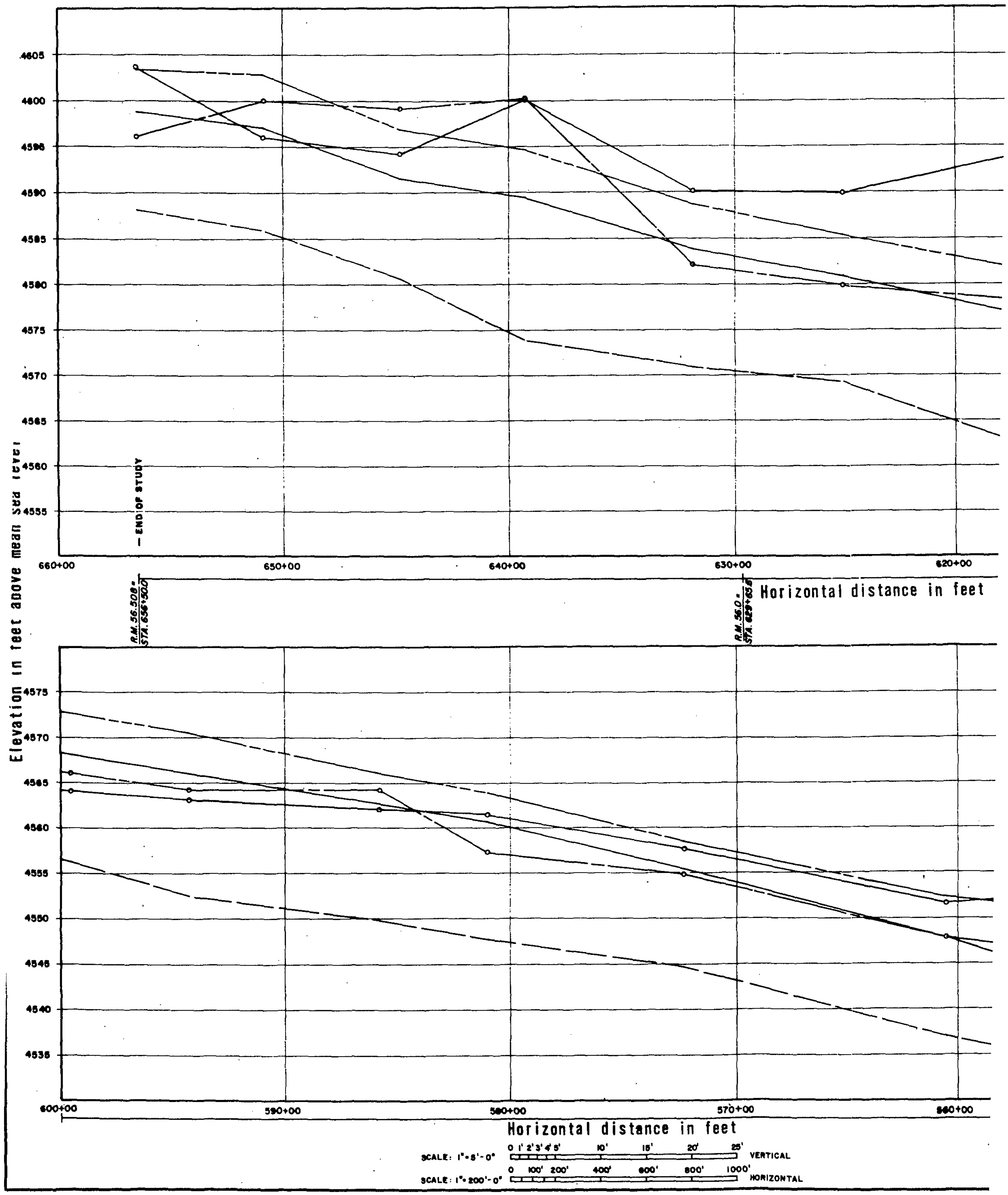
- 100 YEAR FLOOD
- STANDARD PROJECT FLOOD
- EXISTING LEFT BANK
- EXISTING RIGHT BANK
- CHANNEL INVERT
- IMPROVEMENTS - LEFT BANK
- IMPROVEMENTS - RIGHT BANK
- IMPROVEMENTS - LEFT & RIGHT BANKS
- (D) = CROSS SECTION

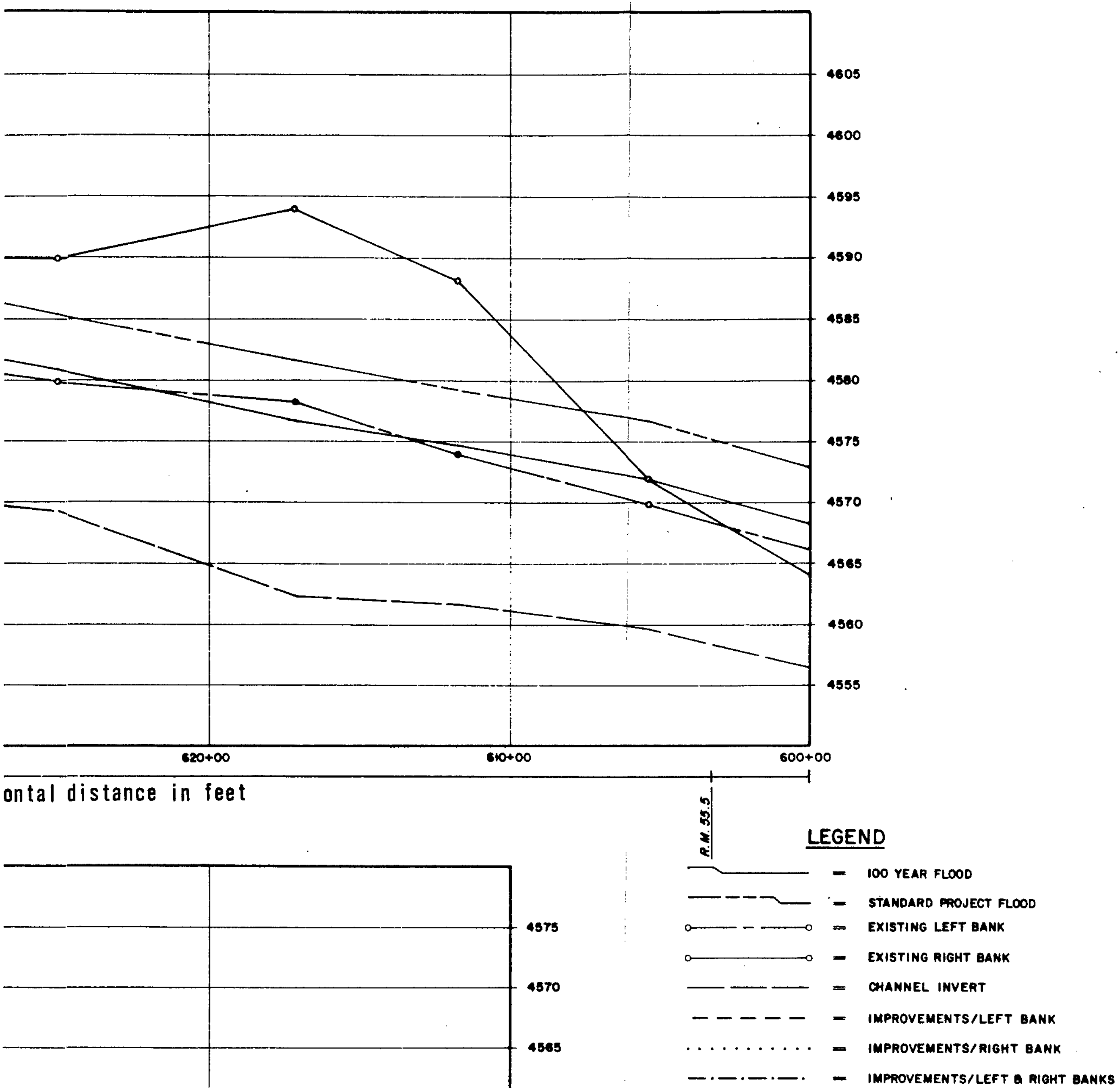
TRUCKEE MEADOWS INVESTIGATION
RENO-SPARKS METROPOLITAN AREA, NEVADA

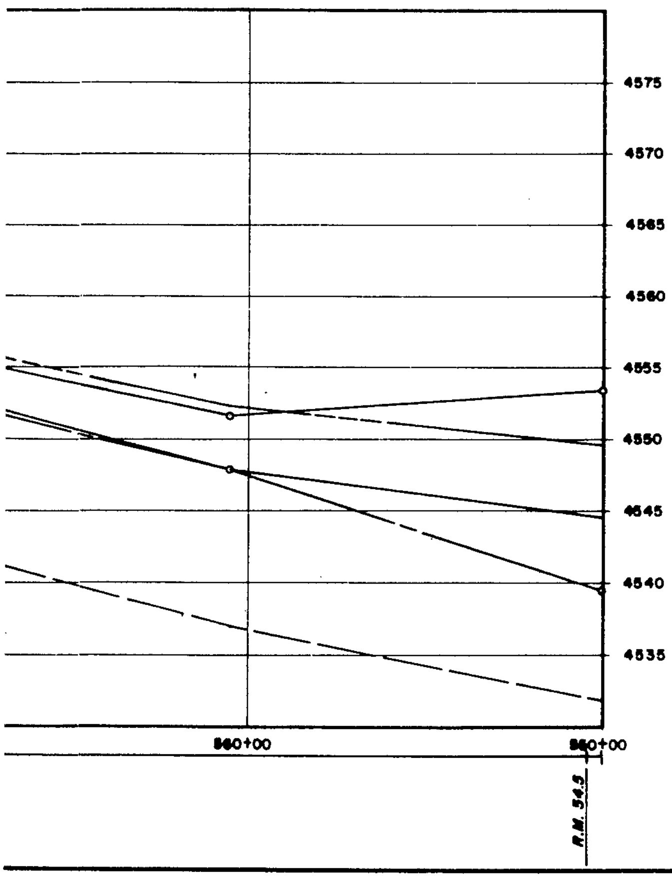
TRUCKEE RIVER
PROFILE
STA. 440+00 to STA. 550+00

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

PLATE 8


Elevation in feet above mean sea level
4605
4600
4595
4590
4585
4580
4575
4570
4565
4560
4555
END OF STUDY
660+00
650+00
640+00
630+00
620+00
R.M. 56.508 - STA. 656+50.0
R.M. 56.0 - STA. 629+65.6
Horizontal distance in feet
4575
4570
4565
4560
4555
4550
4545
4540
4535
600+00
590+00
580+00
570+00
560+00
Horizontal distance in feet
SCALE: 1" = 5'-0"
0 1' 2' 3' 4' 5' 10' 15' 20' 25'
VERTICAL
SCALE: 1" = 200'-0"
0 100' 200' 400' 600' 800' 1000'
HORIZONTAL





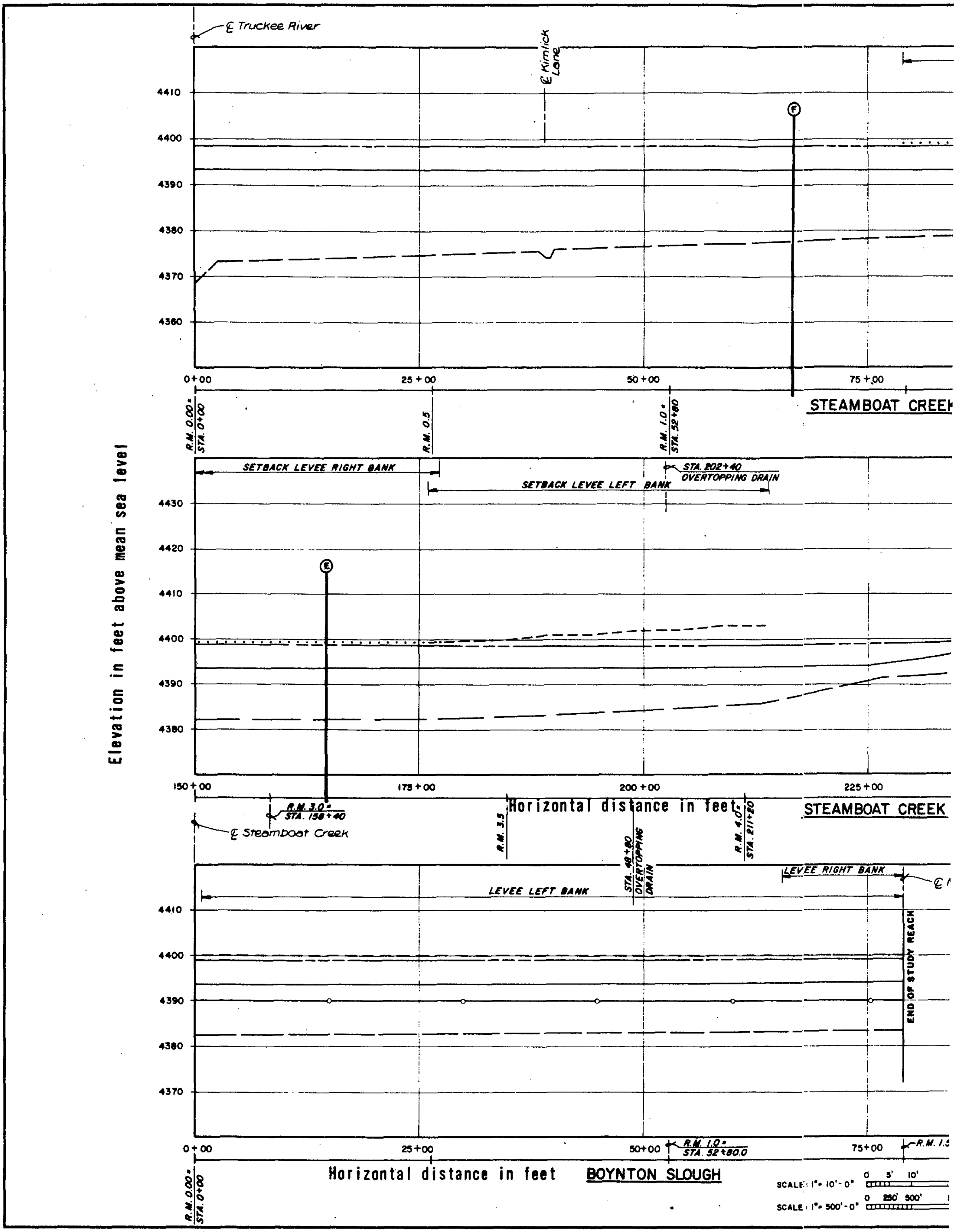
TRUCKEE MEADOWS INVESTIGATION
RENO-SPARKS METROPOLITAN AREA, NEVADA

TRUCKEE RIVER
PROFILE
STA. 550+00 to STA. 660+00

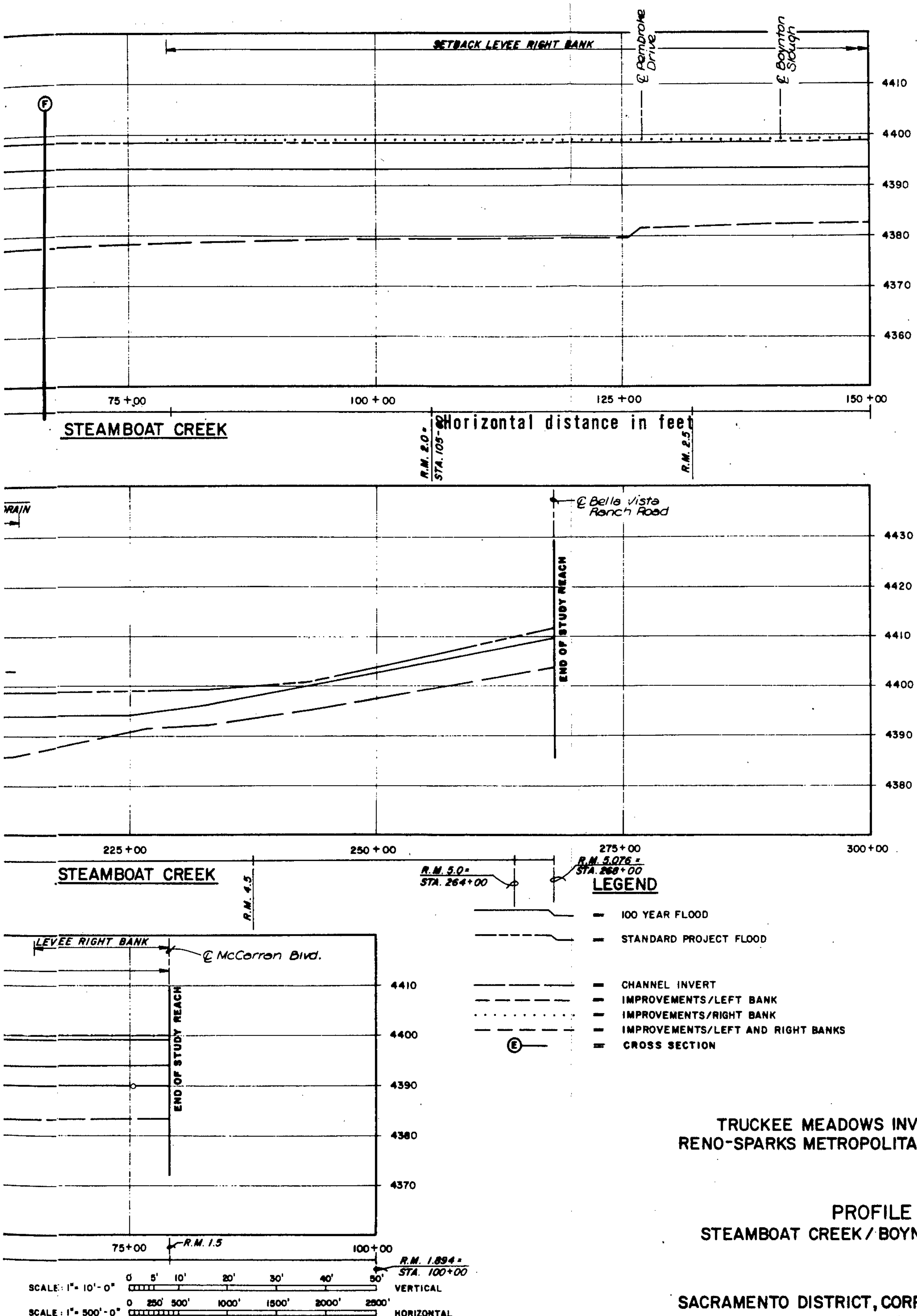
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

2

PLATE 9



℄ Truckee River
℄ Kimlick Lane
STEAMBOAT CREEK
R.M. 0.00 = STA. 0+00
R.M. 0.5
R.M. 1.0 = STA. 52+80
SETBACK LEVEE RIGHT BANK
SETBACK LEVEE LEFT BANK
STA. 202+40 OVERTOPPING DRAIN
R.M. 3.0 = STA. 158+40
℄ Steamboat Creek
R.M. 3.5
Horizontal distance in feet
R.M. 4.0 = STA. 211+20
STEAMBOAT CREEK
STA. 48+80 OVERTOPPING DRAIN
LEVEE LEFT BANK
LEVEE RIGHT BANK
END OF STUDY REACH
R.M. 1.0 = STA. 52+80.0
R.M. 1.5
Horizontal distance in feet
BOYNTON SLOUGH
R.M. 0.00 = STA. 0+00
Elevation in feet above mean sea level
SCALE: 1" = 10'-0"
SCALE: 1" = 500'-0"



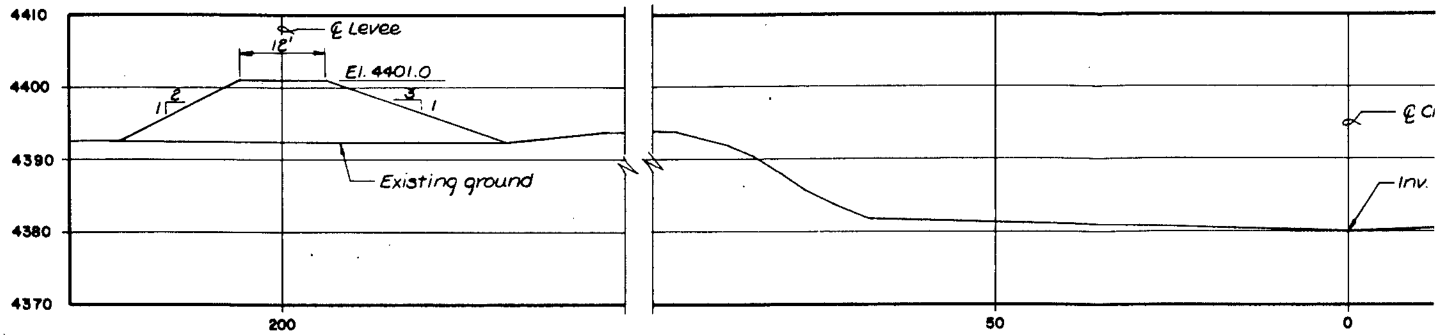
TRUCKEE MEADOWS INVESTIGATION
RENO-SPARKS METROPOLITAN AREA, NEVADA

PROFILE
STEAMBOAT CREEK / BOYNTON SLOUGH

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

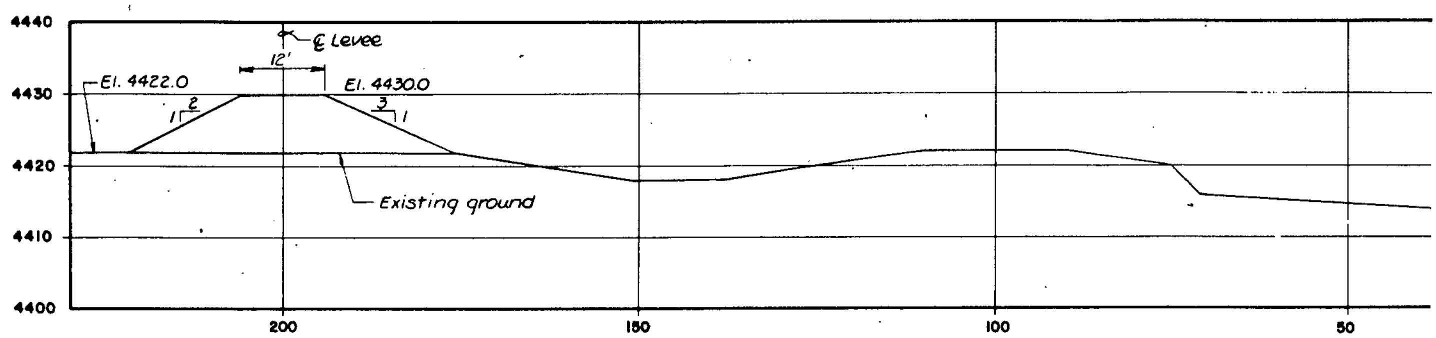
PLATE 10

2



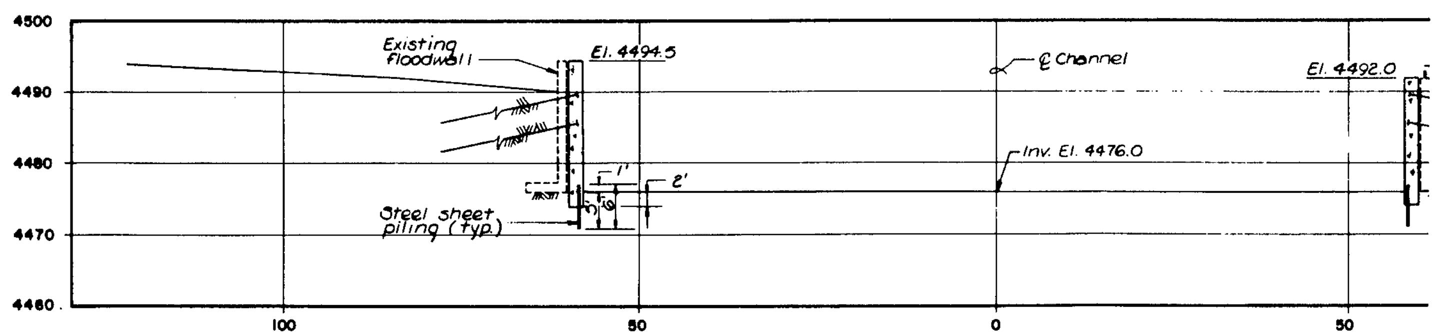
TRUCKEE RIV

CROSS SECTIC



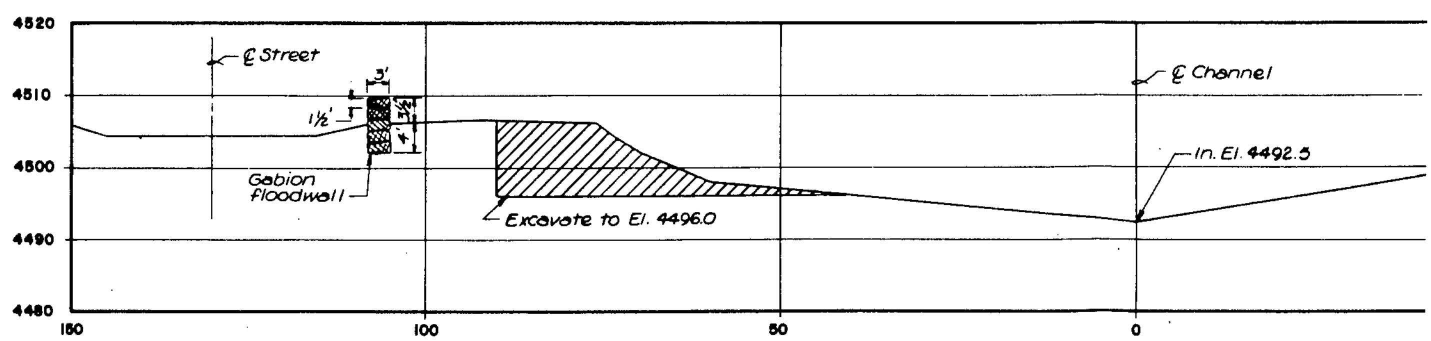
TRUCKEE RI

CROSS SECTI



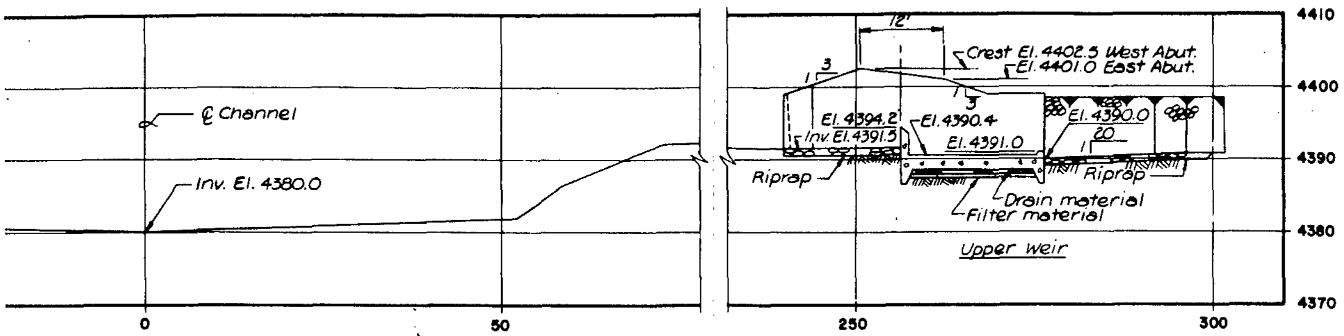
TRUCKEE RIVER

CROSS SECTION C

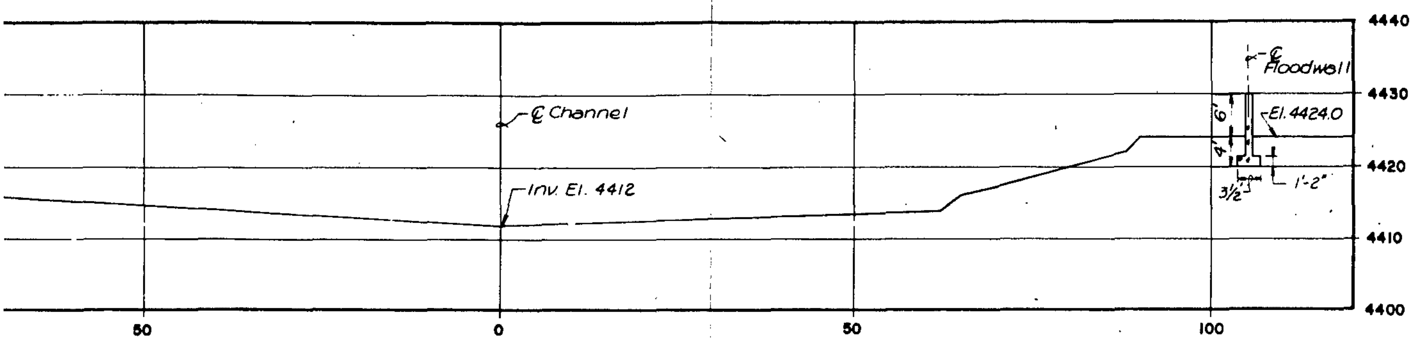


TRUCKEE RIVER

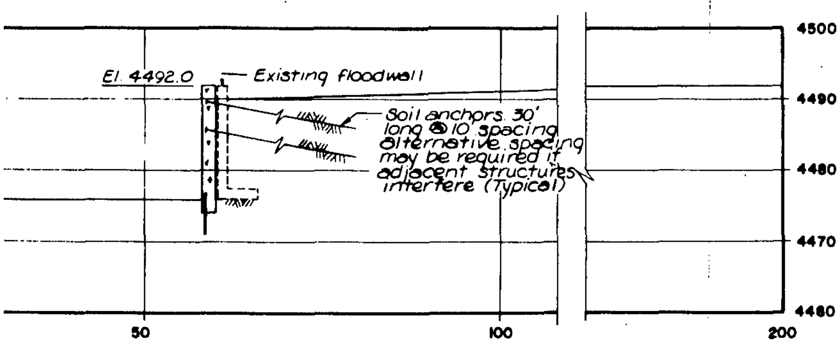
CROSS SECTION D

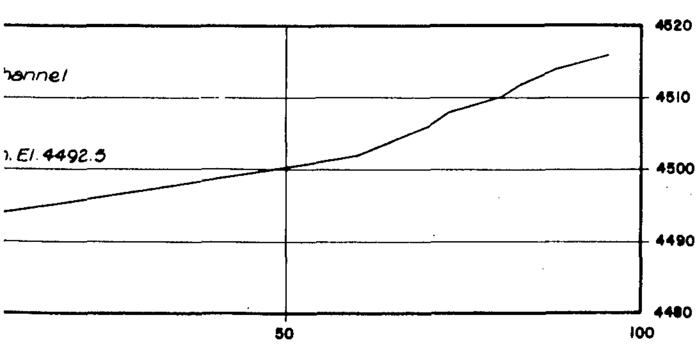


TRUCKEE RIVER
CROSS SECTION A



TRUCKEE RIVER
CROSS SECTION B





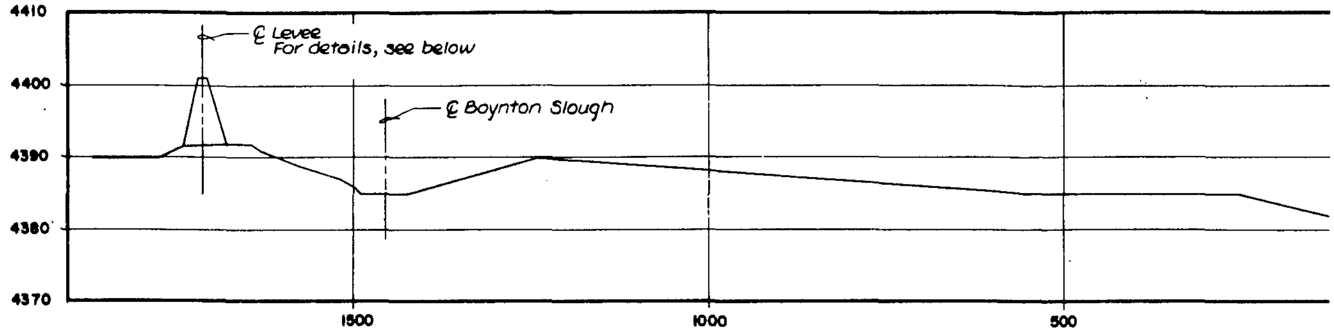
TRUCKEE MEADOWS INVESTIGATION
RENO-SPARKS METROPOLITAN AREA, NEVADA

TYPICAL CROSS SECTIONS

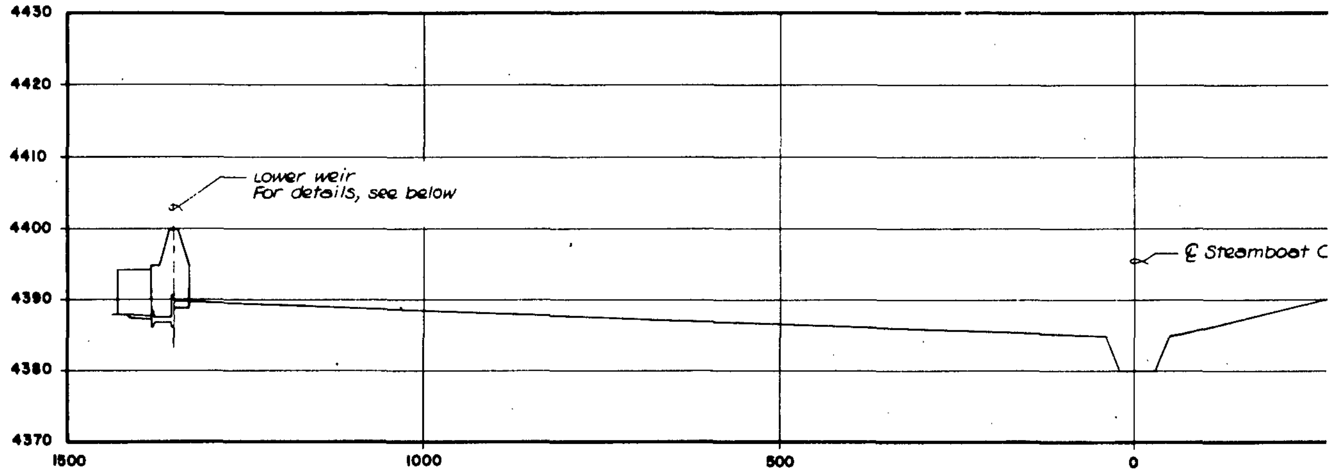
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

2

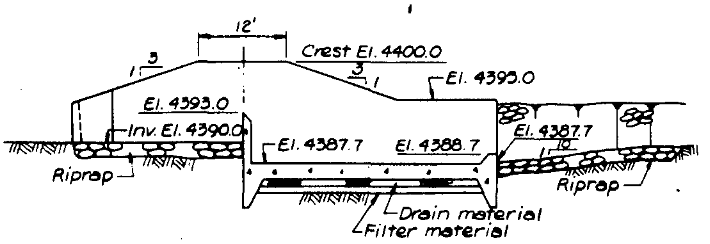
PLATE 11



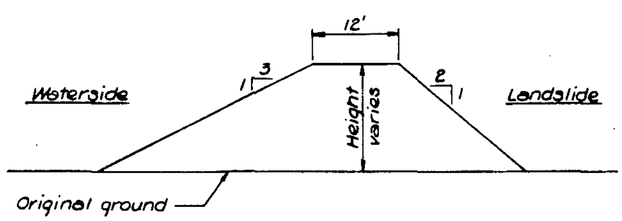
BOYNTON SLOUGH/STEAMBOAT
SECTION E



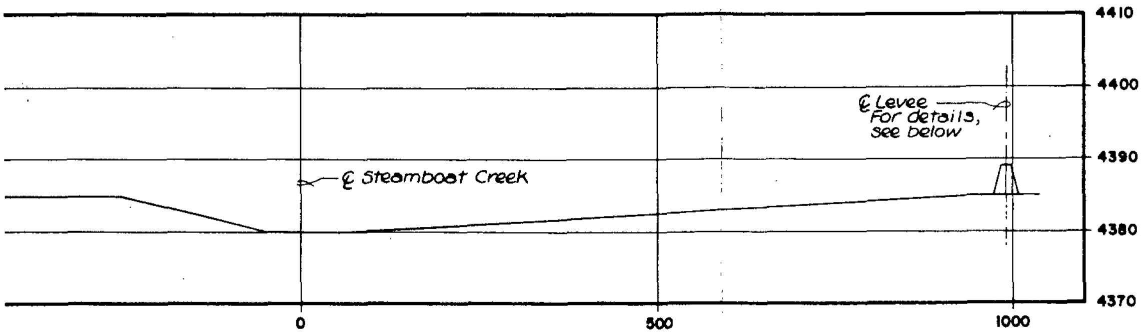
STEAMBOAT CREEK
SECTION F



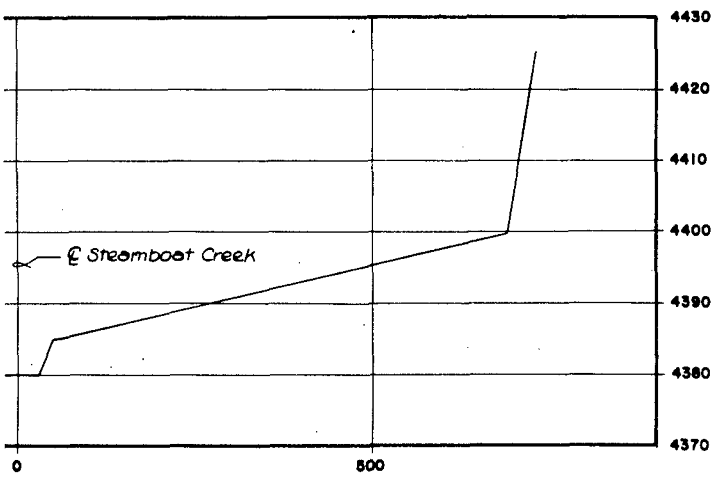
LOWER WEIR
NOT TO SCALE

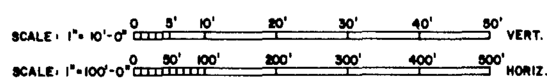


TYPICAL LEVEE SECTION
NOT TO SCALE



GH/STEAMBOAT CREEK
:CTION E





TRUCKEE MEADOWS INVESTIGATION
RENO-SPARKS METROPOLITAN AREA, NEVADA

TYPICAL
CROSS SECTIONS

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

2

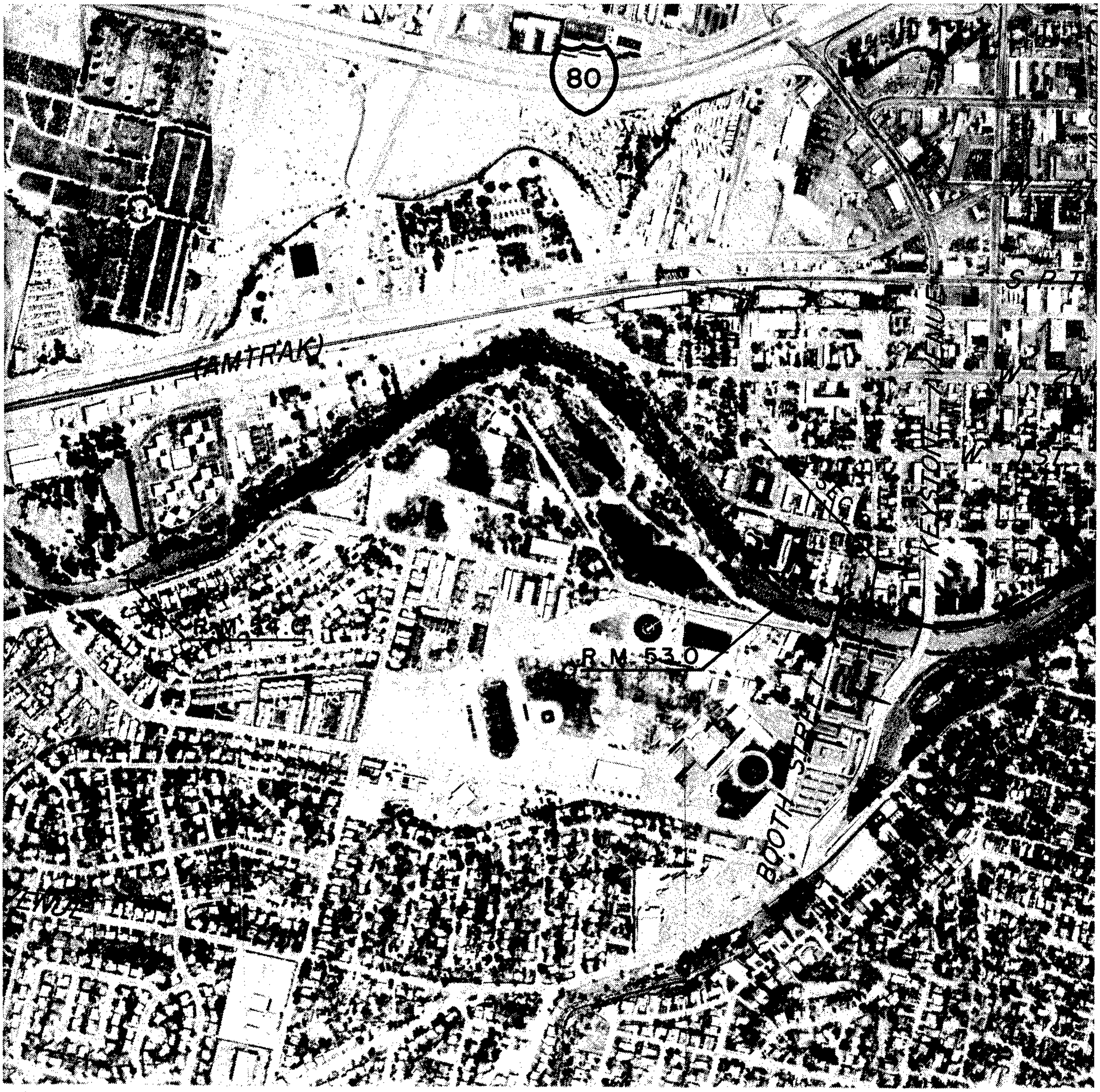
PLATE 12

GRAPHIC SCAL

1" = 800' 0' 400' 800' 1600'

NOTE: AERIAL PHOTOGRAPHY FLOWN, MAY 1981

\



C SCALE

0'   2400'   3200'   4000'

MAY 1981

LEGEND

= PROPOSED L

= PROPOSED C

= PROPOSED F

= PHOTO SHEI

= PROPOSED E

R.M. 55.0 = RIVER MILE

= CROSS SEC

2

)POSED LEVEES
)POSED CHANNEL ENLARGEMENT
)POSED FLOOD WALL
)TO SHEET OUTLINE
)POSED BRIDGE REPLACEMENT
'ER MILE
)SS SECTION (R.M.)

3

TRUCKEE MEADO
RENO-SPARKS METR

CHANNEL

AERIAL PHO

SACRAMENTO DISTRI

OCT

TRUCKEE MEADOWS INVESTIGATIONS
RENO-SPARKS METROPOLITAN AREA, NEVADA

CHANNEL IMPROVEMENT

AERIAL PHOTOGRAPHIC MAP

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

OCTOBER 1983

4

PLATE 13

TRUCKEE MEADOWS INVESTIGATIONS
RENO-SPARKS METROPOLITAN AREA, NEVADA

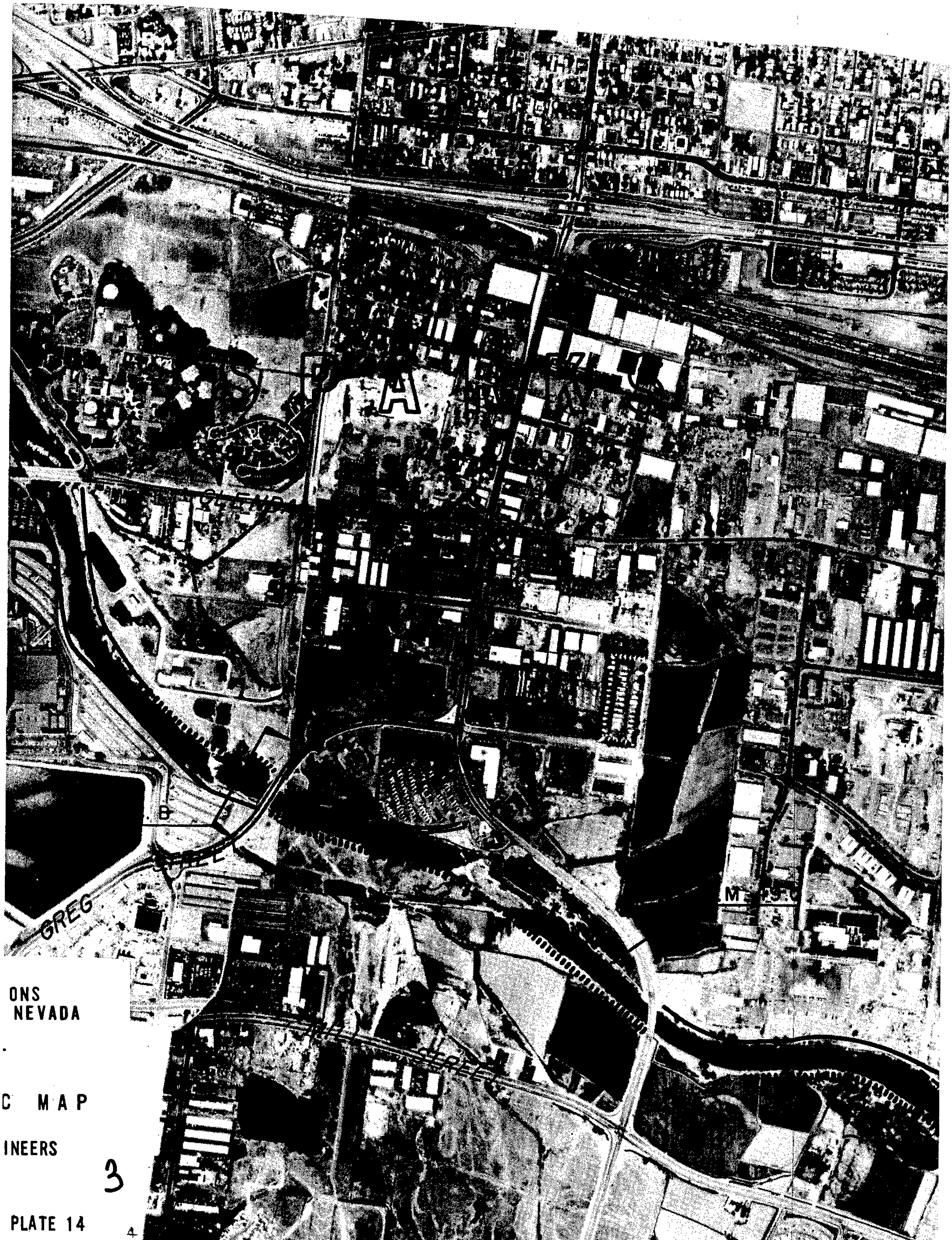
CHANNEL IMPROVEMENT

AERIAL PHOTOGRAPHIC MAP

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

2

PLATE 14



ONS
NEVADA

C MAP

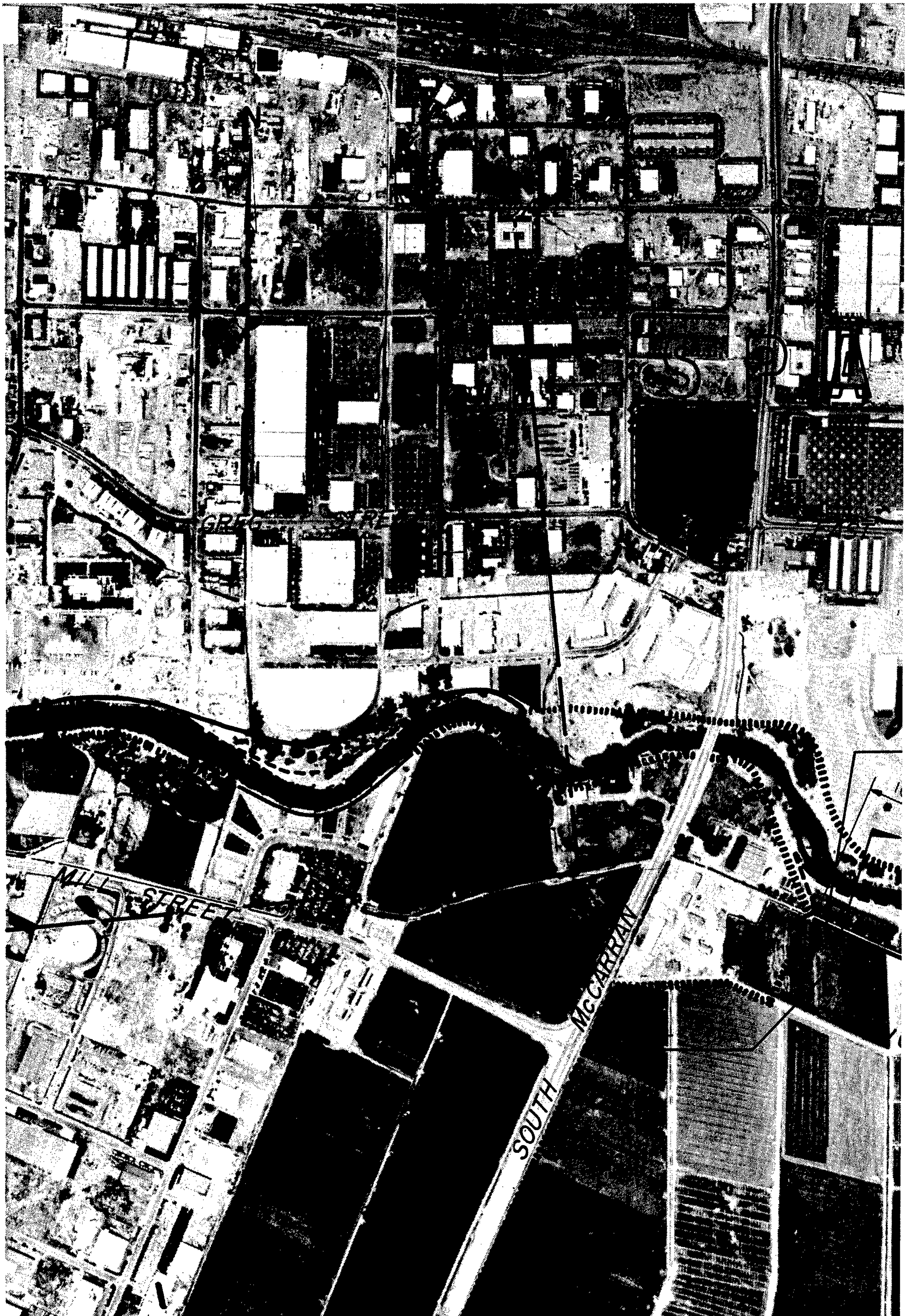
INEERS

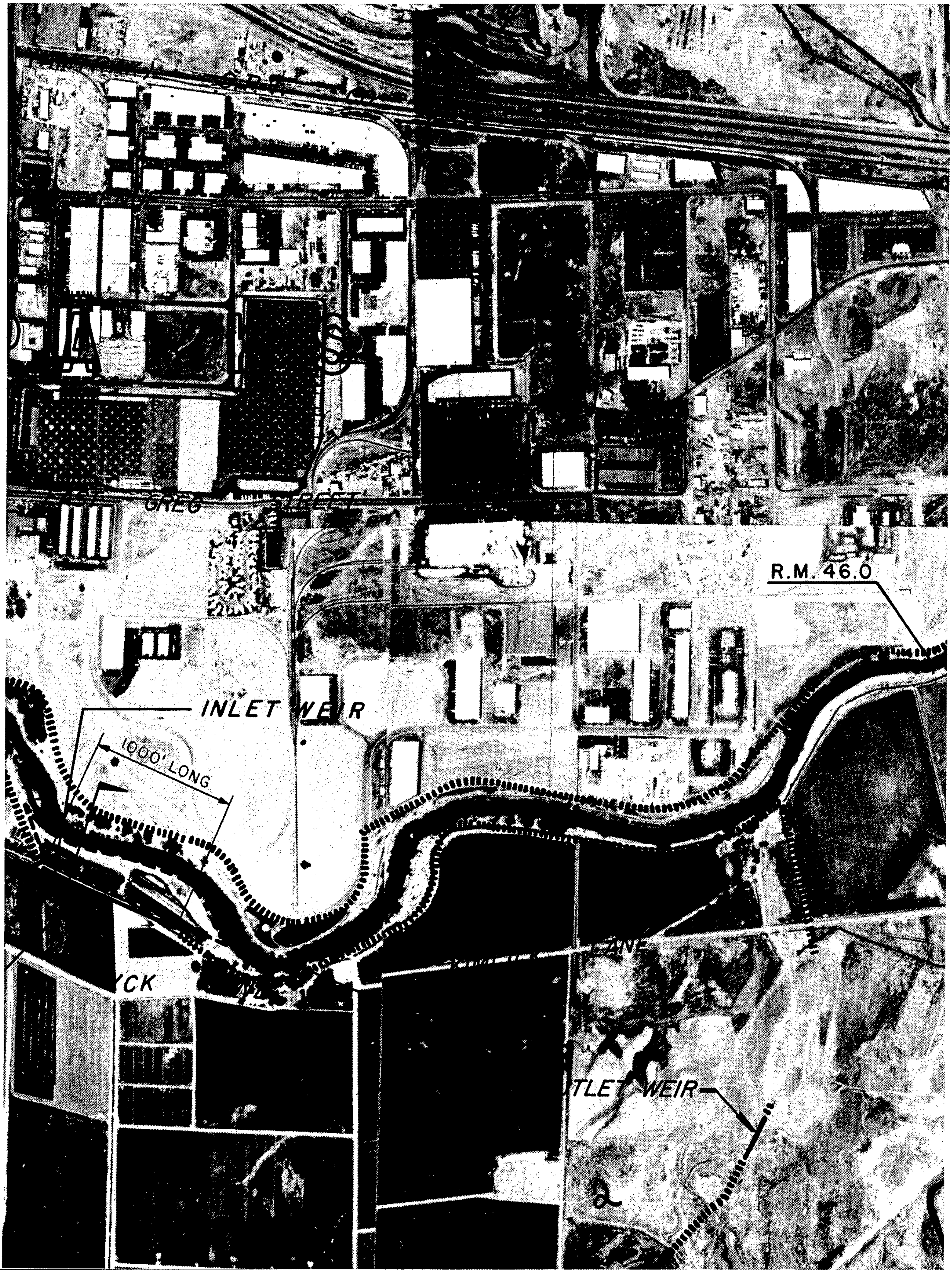
3

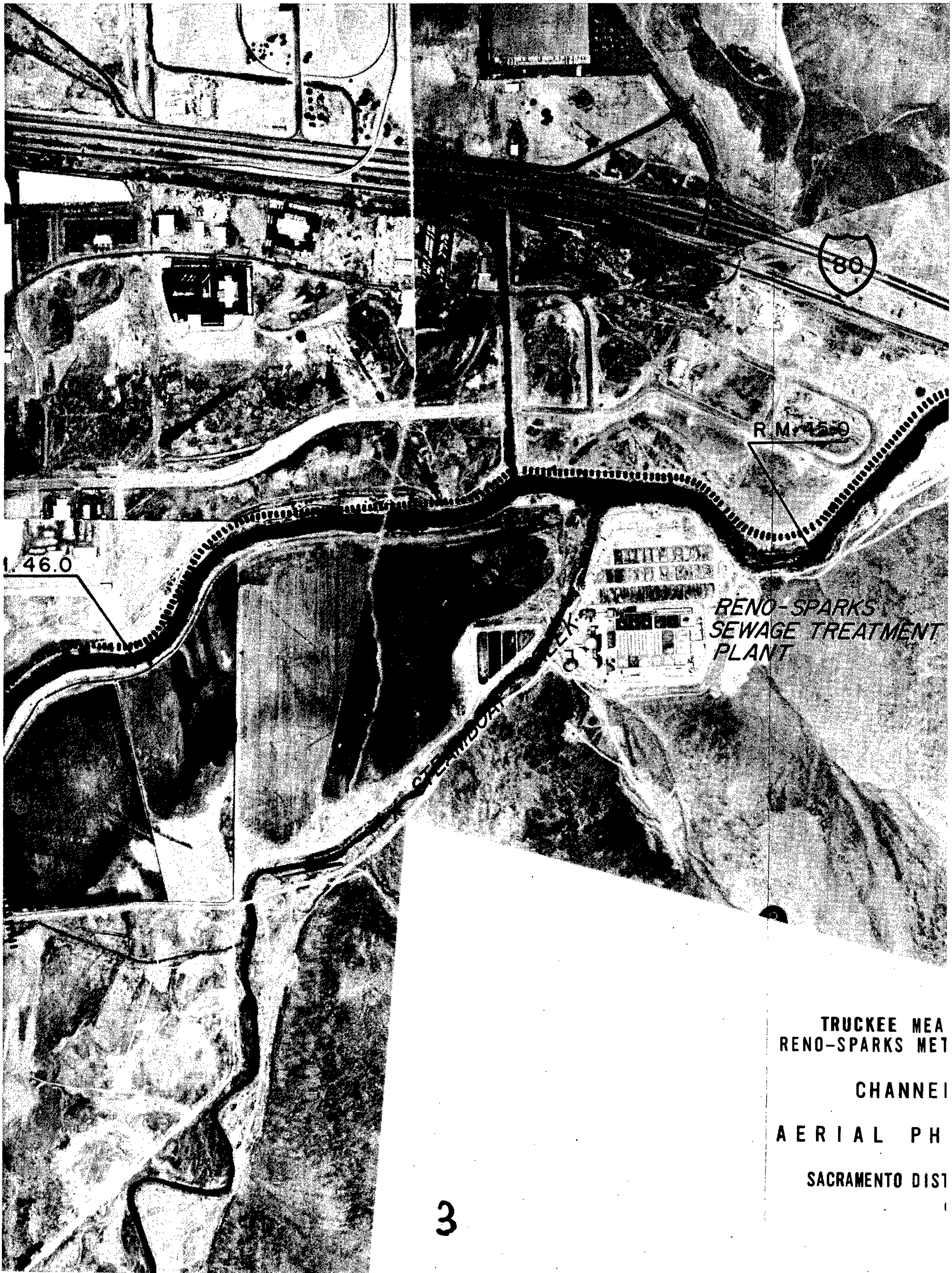
PLATE 14

4

4


MILL STREET
SOUTH McCARRAN


R.M. 46.0
INLET WEIR
1000' LONG
TLET WEIR



TRUCKEE MEA
RENO-SPARKS MET

CHANNEI

AERIAL PH

SACRAMENTO DIST

3

TRUCKEE MEADOWS INVESTIGATIONS
RENO-SPARKS METROPOLITAN AREA, NEVADA

CHANNEL IMPROVEMENT

AERIAL PHOTOGRAPHIC MAP

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

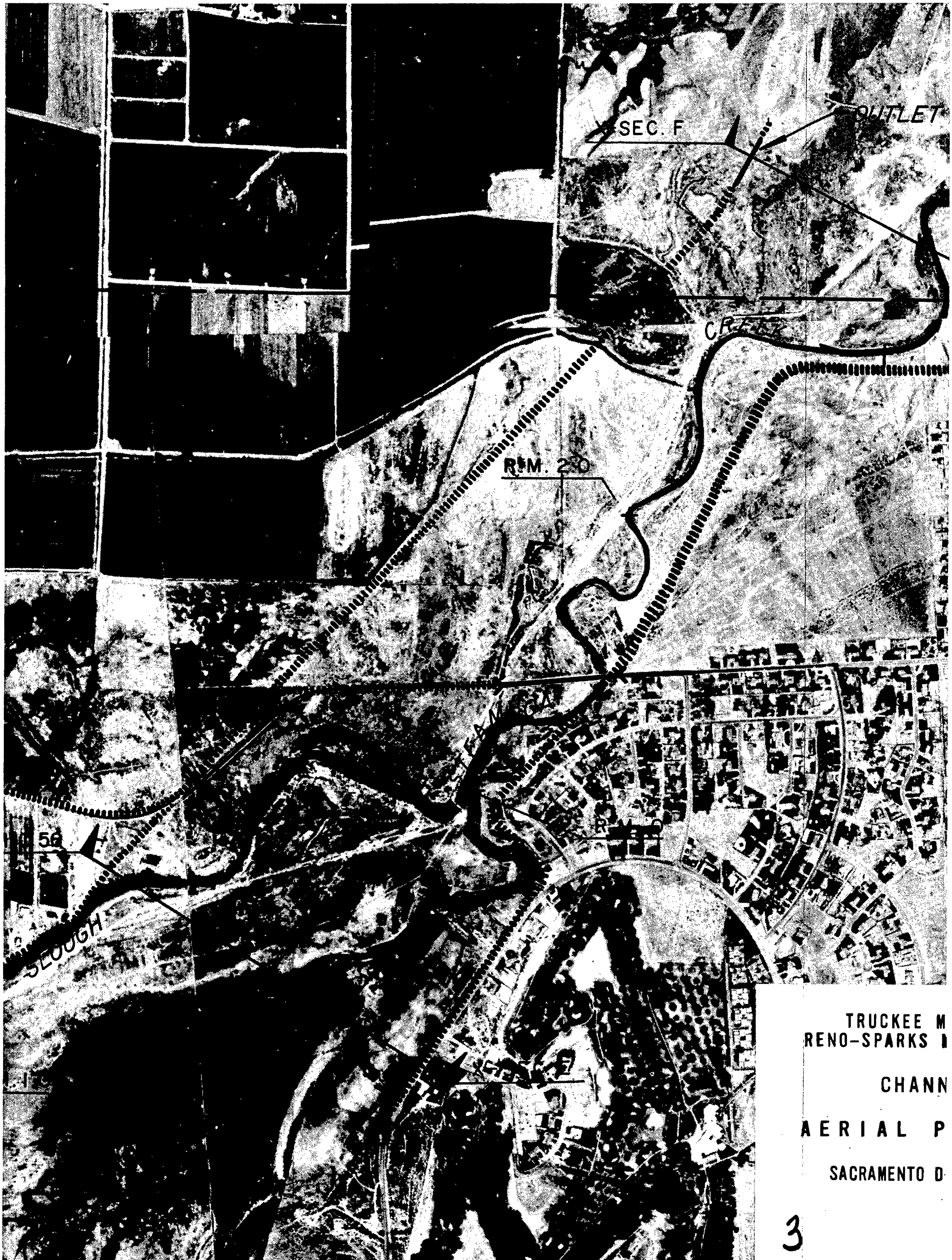
OCTOBER 1983

4

PLATE 15


SOUTH ROCK
INTERNATIONAL AIRPORT
R.M. 2.0

S. McGARRAH BLVD
PEMBROKE DRIVE
SOUTH
SLOUGH
BOYNTON
2


SEC. F
OUTLET
CREEK
R.M. 2.0
SLOUGH
56
TRUCKEE M
RENO-SPARKS
CHANN
AERIAL P
SACRAMENTO D
3

TRUCKEE MEADOWS INVESTIGATIONS
RENO-SPARKS METROPOLITAN AREA, NEVADA

CHANNEL IMPROVEMENT

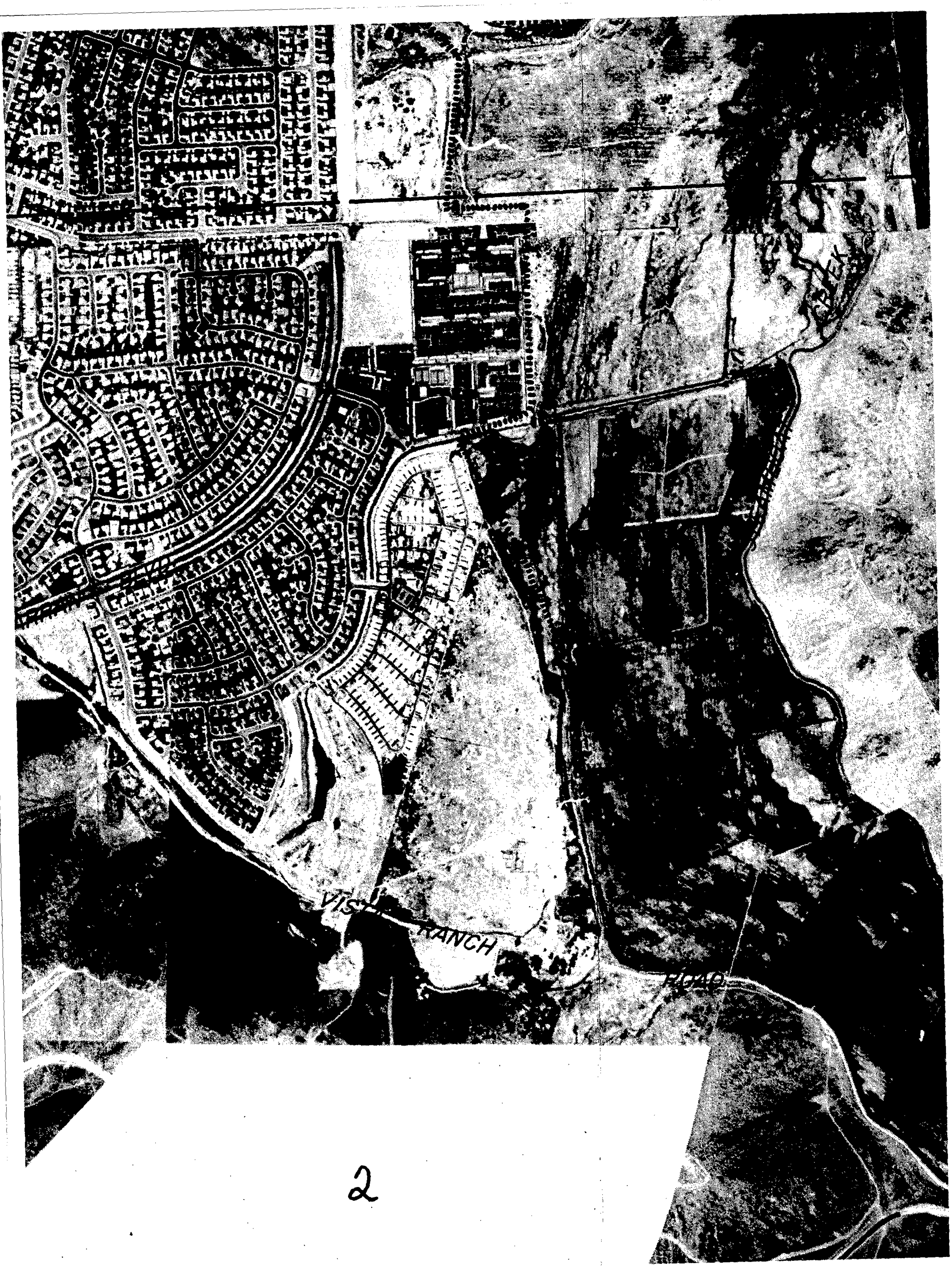
AERIAL PHOTOGRAPHIC MAP

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

4

PLATE 16

1



2

TRUCKE
RENO-SPAR

CH

AERIAL

SACRAMEN

3

TRUCKEE MEADOWS INVESTIGATIONS
RENO-SPARKS METROPOLITAN AREA, NEVADA

CHANNEL IMPROVEMENT

AERIAL PHOTOGRAPHIC MAP

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

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PLATE 17

Section G

Basis of Economic Analysis

SECTION G
BASIS OF ECONOMIC ANALYSIS
TRUCKEE MEADOWS INVESTIGATION

TABLE OF CONTENTS

INTRODUCTION

The purpose of this section is to describe flood damage data and procedures used for computing future annual flood damages for with and without project conditions. This analysis is part of an overall investigation of economic feasibility of the project based upon a 50-year project life (1990-2040), October 1982 price levels, and a 7-7/8 percent interest rate.

The Truckee Meadows-Reno Sparks Metropolitan area has an easterly orientation to the Sierra Nevada mountain range, and as a result the landscape is that of a dry, semi-arid environment. Sections of the area are highly developed, most notably the Cities of Reno and Sparks. Land use includes low and high density residential, tourist-commercial, service-commercial, industrial, and agricultural uses.

FLOOD PROBLEMS

The Reno-Sparks-Truckee Meadows area has had a long history of flooding. The most severe flooding has been a result of unseasonable warm and heavy winter rainstorms. Damaging floods in the study area have generally been one of three types: general rain floods, cloudburst floods, or snowmelt floods.

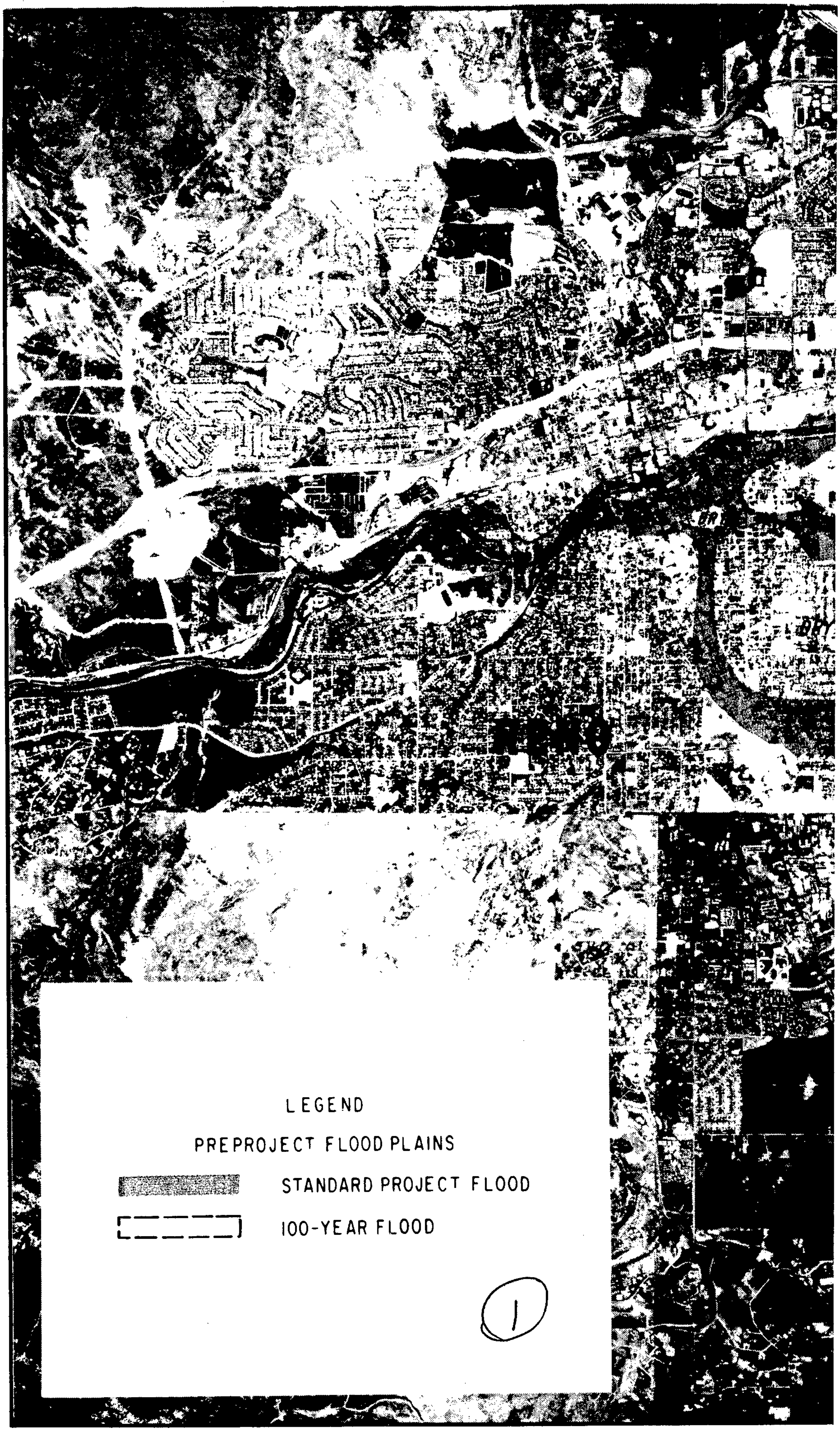
Prior to the 1900's, flooding or periods of high water occurred in the years 1861, 1862, 1867, 1886, and 1890. To date, the largest flood in terms of flow on the Truckee River occurred in December 1955. Bridges were closed, roads were damaged, water flowed freely into unprotected buildings and

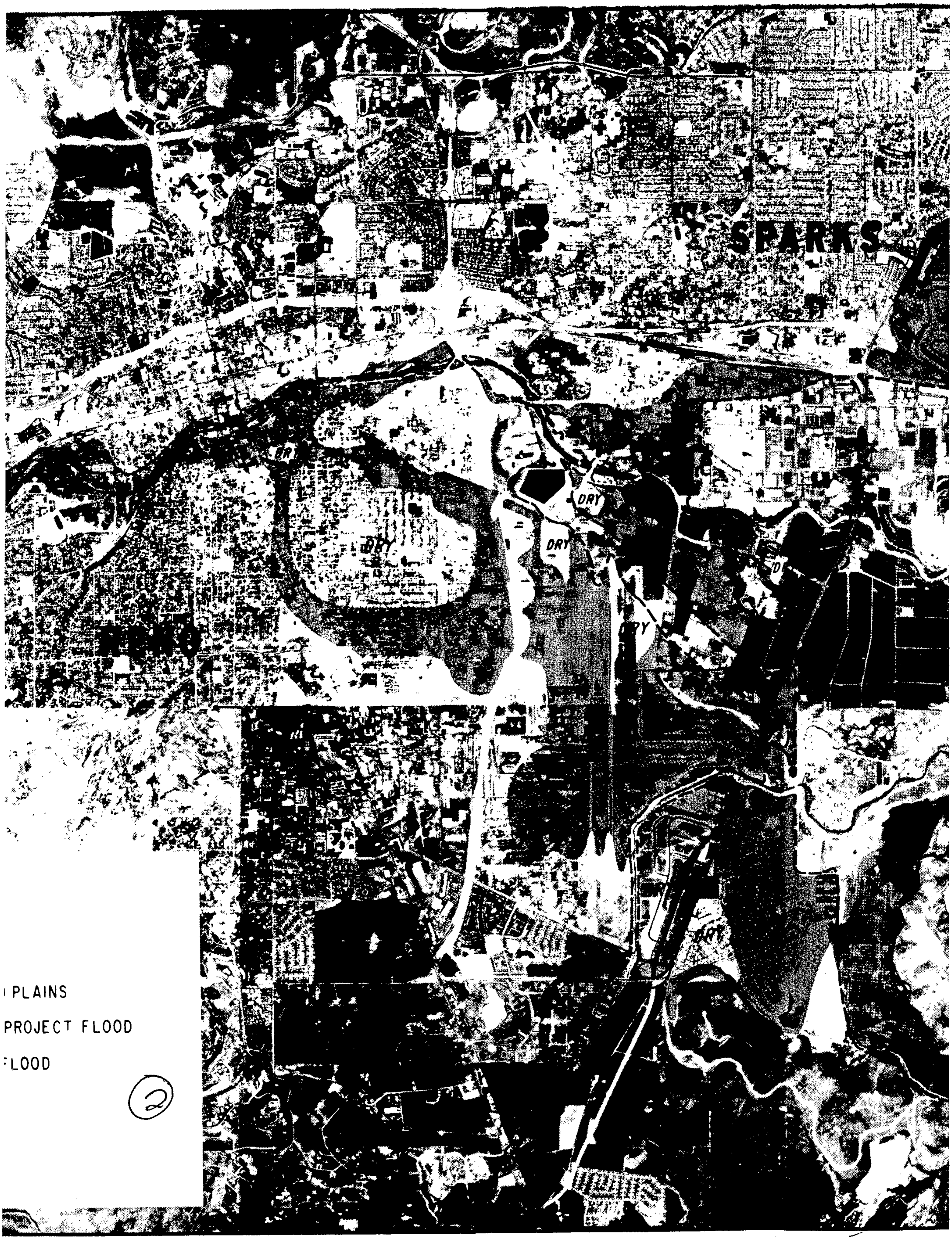
basements in the central commercial district, and streets and lawns were covered with sand and debris. In the Truckee Meadows area, agricultural lands were buried under flood debris and sediment deposits. Irrigation headgates and fences were destroyed, and crops were ruined. The Reno Municipal Airport was also inundated causing curtailment of air traffic for several days.

While the December 1955 flood was the greatest in terms of peak flow, damages were not as high as the earlier flood of November 1950. This fact was primarily due to advance preparations and a well coordinated flood fighting program in 1955.

The November 1950 flood has exceeded all others in terms of damage (2.5 million dollars estimated total damage). Bridges were closed and the Rock Street Bridge was destroyed. Homes and businesses were flooded especially in the central business district. Power and other utilities were damaged; land and irrigation facilities were washed out. Agricultural losses of livestock and crops were extensive.

Other damaging rainstorms have occurred in March 1907, March 1928, February 1963, and December 1964. The largest cloudburst flood to date occurred in 1956. The largest snowmelt flood on record occurred in May 1952. The 100-year and SPF preproject flood plains are shown in Figure 1.


LEGEND
PREPROJECT FLOOD PLAINS
STANDARD PROJECT FLOOD
100-YEAR FLOOD
1


SPARKS
RENO
DRY
DRY
DRY
DRY
DRY
DRY
PLAINS
PROJECT FLOOD
FLOOD
2

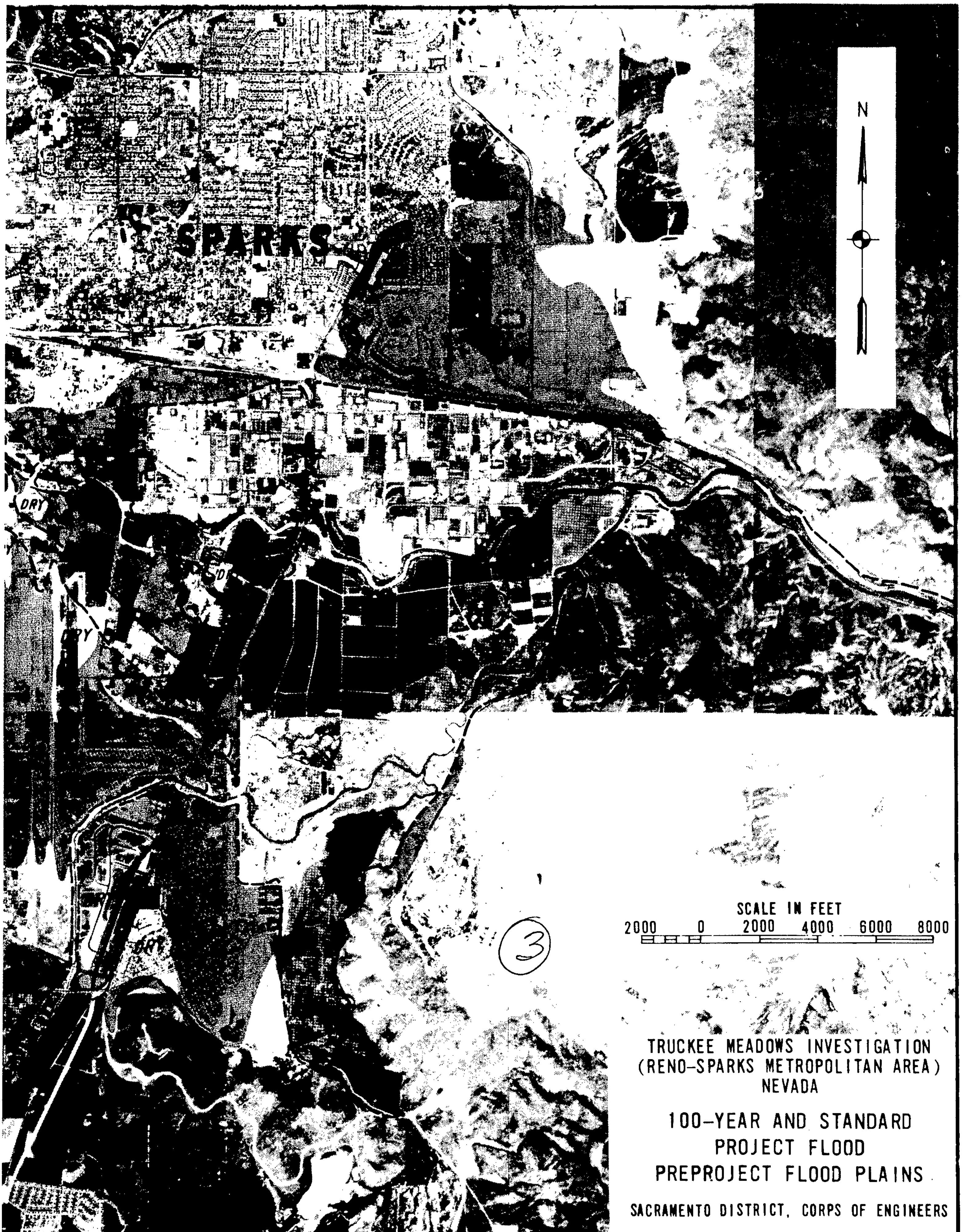

SPARKS
DRY
DRY
DRY
N
SCALE IN FEET
2000 0 2000 4000 6000 8000
③
TRUCKEE MEADOWS INVESTIGATION
(RENO-SPARKS METROPOLITAN AREA)
NEVADA
100-YEAR AND STANDARD
PROJECT FLOOD
PREPROJECT FLOOD PLAINS
SACRAMENTO DISTRICT, CORPS OF ENGINEERS

FIGURE 1

FLOOD PLAIN INVENTORY

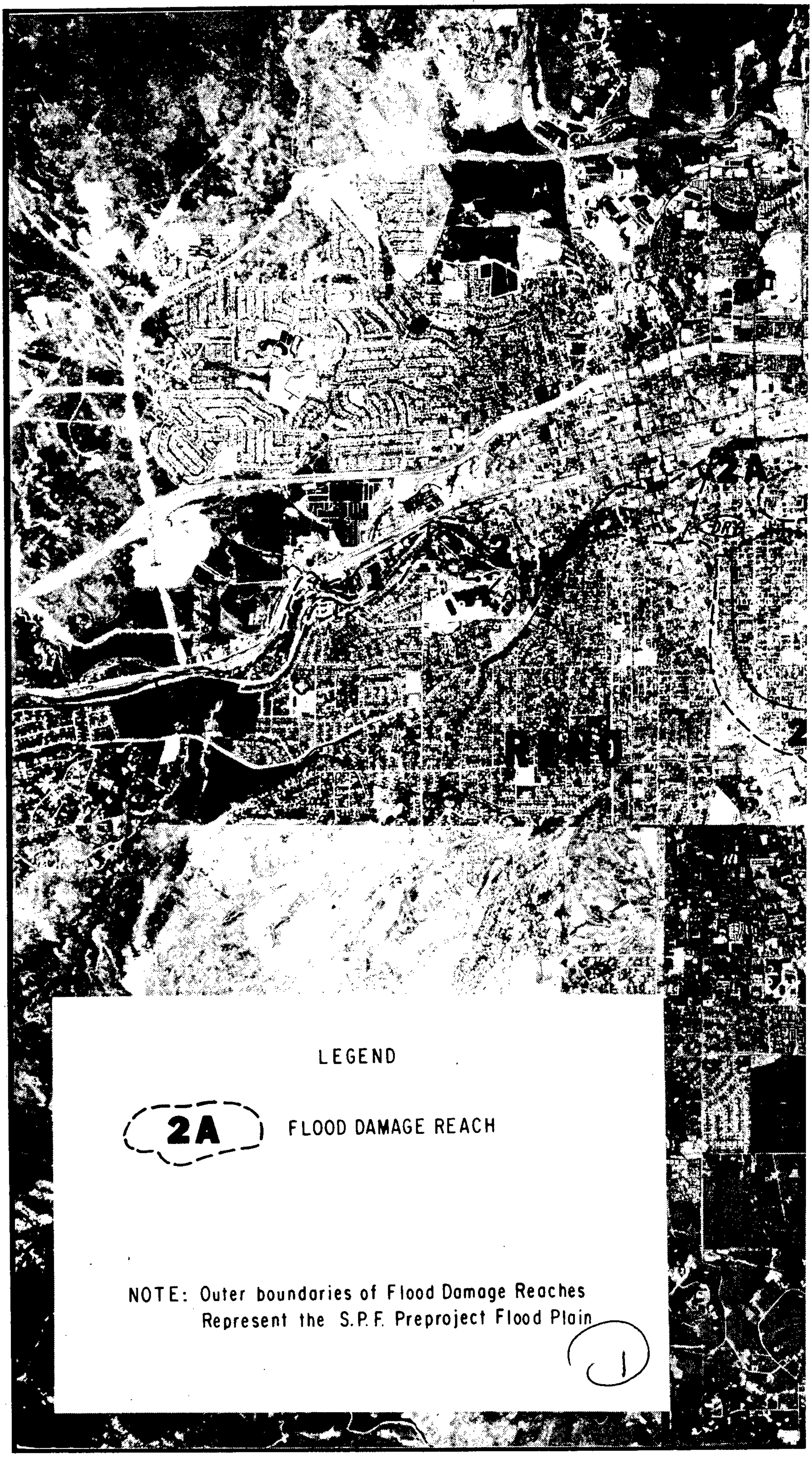
Flood Plain Reaches

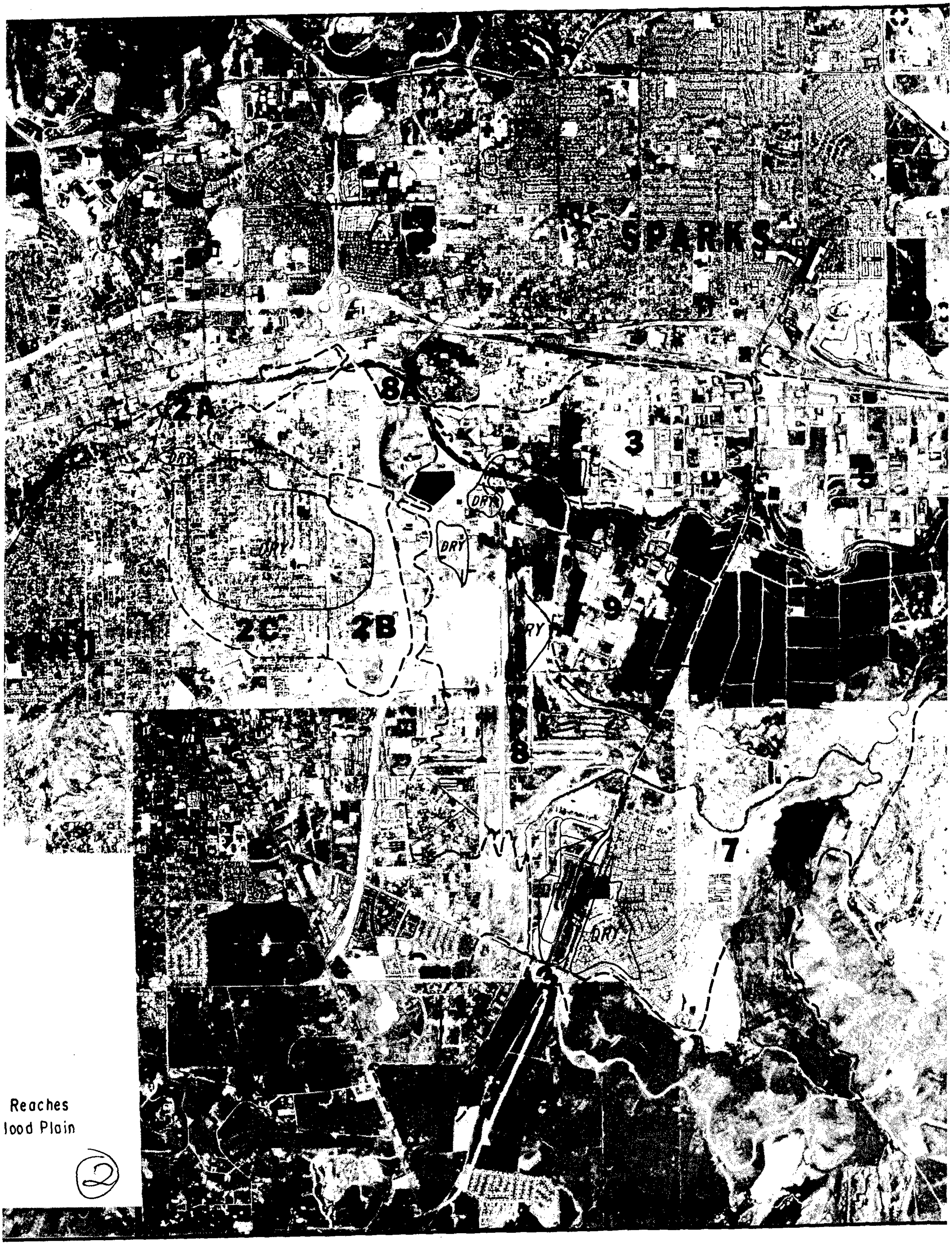
For purposes of economic analysis, the flood plains within the study area have been divided into the 17 reaches shown on Figure 2. Each reach displays various physical and economic characteristics such as land use, depth of flooding, etc., which distinguishes it from the others.

Reach 1 extends from Twin Lakes Drive down to, but not including, Idlewild Park. The river flows from the Sierra Nevada mountain range here and the terrain is moderately steep. The flood plain consists mainly of narrow strips of farmland which are adjacent to the Truckee River. Although this farmland would be subject to flooding, flows would remain within the confines of the river channel. Presently, there is some urban development such as apartments and condominiums, and there is indication for more development.

Reach 2, for purposes of analysis, is subdivided into subreaches 2, 2A, 2B, and 2C. Almost all of reach 2 is found in the dense urban development of downtown Reno. A description of each subreach follows.

Reach 2 lies along the Truckee River between Idlewild Park on the west and Lake Street on the east. This area is recognized as the central business district and has experienced severe flood damages in the past. Most notably, the November 1950 flood inundated the basement of the U.S. Post Office Building, as well as the Ardan Jewelers Building which was known at that time as the Home Furniture Company. Virginia Street, a densely commercial street,


2A
DRY
RENO
LEGEND
2A FLOOD DAMAGE REACH
NOTE: Outer boundaries of Flood Damage Reaches
Represent the S.P.F. Preproject Flood Plain
1



Reaches
lood Plain

2

TRUCKEE MEADOWS INVESTIGATION
(RENO-SPARKS METROPOLITAN AREA)
NEVADA

FLOOD DAMAGE REACHES

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1983

FIGURE 2

runs through "downtown" Reno, and is lined on both sides by casino's and hotels such as Harrah's, Harold's Club, and Cal Neva. Other properties within this reach include more commercial businesses (banks, department stores), some public facilities (Reno High School, Nevada Bell), and on the periphery of the reach a variety of residential areas (apartments, condominiums, mobile homes, and older single family residences).

Reach 2A extends from Lake Street on the west to Kietzke Lane on the east; most of this area is intensively developed although there are also older homes and commercial buildings. Notable properties within this area include the Reno City Police Department, the Reno Evening Gazette, and the Libby Booth Elementary School. This portion of the flood plain will experience a sheet flow of water flowing back into the river from two areas where it overflows the banks, one near Center and Lake Streets and the other in the vicinity of Ryland Street.

Reach 2B is an area which would receive infrequent flooding. After leaving the confines of the Truckee River channel in the vicinity of Wells Avenue and flowing through reach 2A, water would finally enter reach 2B. A portion of the flood plain would experience moderately high velocity flows although the width of the flood plain is quite narrow. This reach begins on the west side of Kietzke Lane and is bounded on the east side by Highway 395 and the north by Mill Street. Some residential areas exist, both single family and multiple units, as well as such public facilities as the U.S. Post Office and two schools (Earl Wooster High School and Roger Corbett Elementary). Also located within this reach are such commercial properties as automobile dealerships, motels, and a large shopping center.

Reach 2C is bounded by Capitol Hill Avenue on the north, Plum Lane on the south, and Kietzke Lane on the east. Once out of bank, water flows parallel to Holcomb Avenue until reaching South Virginia Street where it flows east to Capitol Hill. Along South Virginia Street and Holcomb Avenue primarily commercial properties dominate the landscape. Automobile dealerships, restaurants, department stores, and grocery stores are common businesses in this area. In other parts of the reach, older single family residences and multiple residences are interspersed with some public and semipublic properties. Nevada Bell has another office building in this area, as does the military element of the Corps of Engineers, and the Little Flower Church and School are located in this reach also.

Reach 3 is primarily within the City of Sparks, and is one of the most rapidly developing industrial areas in Truckee Meadows. Both ponding and sheet flow are commonly experienced during flooding. This reach extends on the north side of the Truckee River from Highway 395 to McCarran Boulevard on the east. The north side of the flood plain is partially bordered by the Southern Pacific Railway tracks. This reach is comprised of a variety of commercial properties with the exception of an R.V. Trailer Park. The various commercial operations include farm equipment dealerships (John Deere and Caterpillar), interstate trucking firms (Delta and IMC), distribution warehouses for such companies as Tampax, Smith Kline Pharmaceuticals, and American Bank Stationary, as well as the manufacturing concern of Sweetheart Cup, Hydroconduit Corporation (producers of clay pipes), and Lion Manufacturing (producers of forklifts).

Reach 4 lies immediately south of and adjacent to the Truckee River and north of Mill Street, between Greg Street and Boynton Lane (McCarran Boulevard).

This reach is rapidly changing from a rural agricultural area to an industrial complex, with miscellaneous wholesale and warehouse establishments. Located within this reach are Western Union Telegraph and the Brothers of the Holy Rosary Monastery.

Another reach primarily located within the City of Sparks is Reach 5. It extends from McCarran Boulevard to the entrance of the canyon near Vista. This reach lies north of the Truckee River and south of Interstate 80. At one time predominately a rural cropland area, land use projections indicate complete industrial development by project year one. It presently houses the 1.6 million square foot Pacific States Regional Warehouse of K-Mart. Other large complexes include: the interstate trucking firms of Pacific Intermountain Express (P.I.E.), Consolidated Freight (C.F.), Detroit Roadway and System 99; the paper and lumber firms of Crown Zellerback, Georgia Pacific and 84 Lumber; such food supply companies as Butrey and Foremost; and miscellaneous operations such as Ralston Purina and the SPCA Animal Shelter.

Reach 6 remains predominately an agricultural area and comprises the land owned and operated by the University of Nevada's Agricultural Experiment Station (UNV-AES). It lies south of and adjacent to the Truckee River, bordered on the west by McCarran Boulevard, on the east surrounding the foothills by Steamboat Creek and on the south by Pembroke Drive and Hidden Valley Estates. Crops in this reach are mainly forage related. Although the future land use is projected to remain agricultural, it remains to be seen if

this area will also yield to developmental pressures being felt in other reaches within the flood plain. Currently, there is a very small number of rural residential homes in this reach. Because of the flat terrain of Reaches 5, 6, and 7, overflow from the Truckee River has historically ponded to a depth of several feet. In the past this area was known as Vista Lake because of the resultant ponding during historical floods.

Reach 7, which lies south of and adjoining Reach 6, was once predominately agricultural land. It is bordered by Pembroke Drive on the north, Boynton Lane (Longley Lane) on the west, the foothills along Hidden Valley Estates on the east and Huffaker Hills to the south. This area has grown rapidly in the last five years, and there is additional pressure to further develop the remaining lands, with the exception of the wetlands. Current residential developments include Donner Springs subdivisions, Hidden Valley Estates and golf course development, and miscellaneous condominiums and mobile home complexes. Flood problems in this reach are augmented by flows from Steamboat Creek and Boynton Slough. In normal as well as wet years, a high water table caused by poor interior drainage facilities creates the wetlands. As this area is developed, drainage systems are being developed which may completely change the ecosystem of the area.

Reach 8 has been broken into two subreaches for purposes of this analysis. The first of these, subreach 8, is bordered on the east by Boynton Lane, and on the northeast by South Rock Boulevard and the Truckee River. The principal occupant of this area is the Cannon International Airport which has experienced substantial flooding from historical events. Also located within subreach 8, are commercial properties, low density residential units,

and the public facilities of the Reno Municipal golf course, the Reno Animal Shelter, and Washoe County's maintenance yard.

Subreach 8A is a small area located south of the Truckee River. It extends north to Glendale Avenue and east to Highway 395. The most notable structure in this subreach is an office building occupied by the State of Nevada.

Reach 9 lies between Reach 4 and Mill Street to the north, Boynton Lane/McCarran Boulevard on the east and on the southwest by South Rock Boulevard. There is presently some agriculture. However, some lands which were once part of the University of Nevada Experimental Farm have been sold recently to urban development interests. It is a developing industrial area as noted by the many businesses and warehouses. Sierra Pacific Power has a large facility in the area, as do such companies as Hexcel Sports, National Cash Register, and Pepsi-Cola Bottling Company.

Reach 10 experiences infrequent flooding from the Truckee River. In the event of a Standard Project Flood, however, flows would overtop Interstate 80, the southern boundary, and extend northward for about one mile. Near the eastern boundary of McCarran Boulevard, considerable fill has been added to an area encompassing approximately one hundred acres, to provide for an industrial park. Currently, the two major occupants of this area are General Motors' Parts Plant and B. F. Goodrich. Also located within Reach 10 is a large gravel operation which would serve as a natural reservoir in times of extreme flooding. Along the western border of the reach, McCarran Boulevard, there is a mixture of residential properties; single family homes and multiple structures, some of older construction, others recently built. A

large shopping center, Silver State Plaza, is also located in this area. Floodwaters would inundate the meadowlands and will cause some minor flooding problems to this predominately residential area. Water would generally follow the flow regime of the north Truckee drain, a tributary which flows into the Truckee River from the north.

Reach 11, south of Reach 7, extends to the foothills on the east and west of Steamboat Creek. Its southern border is Short Lane. It is primarily an agricultural area of which alfalfa is the major crop. Native vegetation also supports some range cattle here.

Reaches 12 and 13 also experience infrequent flooding from the Truckee River. In the event of a Standard Project Flood, however, flows would reach this area. Reaches 12 and 13 begin south of Peckham Lane and extend south to Virginia Street (Business 395). Reach 12 encompasses the Evans Creek basin and Reach 13 the Dry Creek basin. There is a mixture of residential properties in these reaches. A large shopping center, Meadowwood Mall, on the western border of Reach 12, serves this area. Floodwaters would inundate the meadowland in these reaches and will cause some minor flooding problems to this predominantly residential area.

Land Use in the Flood Plain

The measurement and projection of damages resulting from inundation are based upon relationships between present and future land use characteristics and the vulnerability of properties within the flood hazard area to damages.

A summary of existing and future land use acreages for individual categories in the defined standard project flood plain is shown in Table 4.

Total acreage within the flood plain is approximately 8,574 acres. From this acreage seventeen reaches have been designated, each one unique based upon hydrology, flood depths, type of flooding, etc. Land use within these reaches vary, but is basically comprised of a mixture of the following: residential, multiple, mobile home, commercial, industrial, public and agricultural.

Housing structures make-up approximately nine percent of the land use in the flood plain. Of the three components in this category, single family residential makes up the largest portion. Multiple residential refers to apartment buildings or condominium complexes and together with mobile homes each make-up an equal, but lesser percentage than that of single family. Mobile homes and trailers are of varying sizes. The average mobile home is approximately 1,800 square feet, while trailers range in size from 5 to 6 hundred square feet.

The commercial land use category comprises approximately six percent, and includes retail trade, service oriented establishments, as well as motor freight transportation facilities. Reach three contains the highest number of acres devoted to commercial activities. Retail trade includes businesses engaged in selling merchandise for personal or household consumption. Examples of this in the Reno area include general merchandise stores, food stores, automotive dealers and gasoline service stations, apparel and accessory stores, furniture and applicance stores, and eating and drinking establishments.

TABLE I

EXISTING & FUTURE LAND USE IN THE STANDARD PROJECT FLOOD PLAIN

(Acres)

DESIGNATION	EXISTING LAND USE (1982)	FUTURE LAND USE					
		1990	2000	2010	2020	2030	2040
RESIDENTIAL	810	1,092	1,092	1,092	1,092	1,092	1,092
COMMERCIAL	482	842	842	842	842	842	842
INDUSTRIAL	1,177	2,423	2,423	2,423	2,423	2,423	2,423
PUBLIC	2,689	2,903	2,903	2,903	2,903	2,903	2,903
AGRICULTURE[1/]	3,416	1,314	1,314	1,314	1,314	1,314	1,314
TOTAL ACREAGE	8,574	8,574	8,574	8,574	8,574	8,574	8,574

[1/] Includes vacant, native vegetation, fallow field, and stream channel.

SOURCE: Based upon aerial photographs, city and county assessors' rolls, the general development plans for the City of Sparks, the City of Reno, and Washoe County, local and regional population projections, direct interviews, and field survey.

Service oriented establishments provide a variety of services for individuals, business establishments and other organizations. Hotels and motels with associated gaming operations, alone make-up a large portion of the commercial category. This activity is largely centered in Reach two where approximately twenty-one acres are devoted to the gaming establishments. While no less important to the area, other service establishments provide repair, health, and legal services.

Another important land use activity in addition to the gaming establishments, is the local and long distance trucking firms. Due to its excellent geographic proximity to many western markets, the Reno area provides an excellent terminal point for the following firms: P.I.E., C.F., Delta, System 99, and Detroit Roadway.

The industrial land use category comprises approximately fourteen percent of the total acres in the flood plain. The majority of these acres are located in Reach 3 where industrial land use comprises more than half of the total acres in that reach. Industrial uses are broken down into three major activites: manufacturing, wholesale trade, and warehousing.

The first of these, manufacturing, represents establishments engaged in the mechanical or chemical transformation of materials or substances into new products, as well as those engaged in assembling component parts of manufactured products. Finished products are sold on the wholesale market or transferred interplant, while semi-finished products become raw material for another industrial type establishment. Some items produced in the Reno area include plastic and styro-foam cups, oil valves, skiing equipment, prepared animal feed, cash registers, and forklifts.

Wholesale trade, another component of industrial activity in the Reno area includes establishments primarily engaged in selling merchandise to retailers, to industrial, or commercial users, or to other wholesalers.

Establishments such as these in the Reno area include Addressograph-Multigraph Corporation, U.S. Machinery Company, the Grocery Lines of Butrey and Foremost Products, and the farm machinery and equipment companies of John Deere and Caterpillar.

In addition to sales, some of these establishments also maintain inventories of goods; physically assembling, sorting, and grading goods in large lots; breaking bulk items into smaller lots for redistribution; and delivery. This describes some of the functions of the third industrial activity, warehousing. Establishments such as B. F. Goodrich Company, K-Mart Corporation; Tampax, Inc., operate as distribution facilities for each of their respective manufacturing plants.

Public land use is made-up of a variety of public and semi-public organizations and services. Overall, public lands and properties total approximately thirty-one percent of the flood plain acres, second only to agricultural acreage. Together, Reaches 6 and 8, contribute to more than one half of the total acres in public land use. The University of Nevada Experimental Station lies within Reach 6, and Cannon International Airport occupies the majority of land in Reach 8. Represented under the broad heading of public are communication and utility services, as well as transportation, recreation, and educational services. Examples of the latter three include roads, parks, schools, and churches.

The final land use category included in this analysis is agricultural lands. This is the largest category representing approximately forty percent of the total acres in the flood plain. One would therefore expect an opportunity for future development within the flood plain area. This is not the case, however, with several of the reaches. For example, Reach 7 represents the largest number of agricultural lands in the flood plain, but the major portion of these lands are to be retained as protected wetlands. Reach 8 is also limited by aviation easements maintained by the Cannon International Airport.

Agricultural uses in the flood plain are primarily located in the southern and eastern parts of the meadows where urban development pressures have not yet intensified. Due to the short growing season, crops are limited to hay crops; a common variety is alfalfa hay. Much of the land is also utilized as a pasture, primarily for cattle grazing.

Physical Units

Existing damageable units within the flood plain total approximately 5,296; Table 2 shows the breakdown of this figure by major land use category. Residential units comprise the largest portion of the total, or approximately 82 percent. The majority of these units are in Reach 7 where approximately 48 percent of the total single family homes are located. Reach 10 also has a high proportion of single family residential units, as well as multiple residential units.

Residential properties which were noted earlier in this analysis are briefly discussed here for further clarification. Single family housing

TABLE 2

EXISTING & FUTURE DAMAGEABLE UNITS IN THE STANDARD PROJECT FLOOD PLAIN

(Units)

DESIGNATION	EXISTING (1982)	FUTURE LAND USE					
		1990	2000	2010	2020	2030	2040
RESIDENTIAL:							
Single Family	2,586	3,448	3,448	3,448	3,448	3,448	3,448
Multiple	1,326	1,899	1,899	1,899	1,899	1,899	1,899
Mobile Homes	419	530	530	530	530	530	530
COMMERCIAL	606	795	795	795	795	795	795
INDUSTRIAL	244	574	574	574	574	574	574
PUBLIC AND SEMI-PUBLIC[1/]	115	115	115	115	115	115	115
TOTAL UNITS	5,296	7,361	7,361	7,361	7,361	7,361	7,361

[1/]Growth of public facilities not projected for flood plain since majority of existing structures currently have new construction of support facilities outside of flood plain due to cost and availability of land.

SOURCE: Based upon aerial photographs, city and county assessors' rolls, the general development plans for the City of Sparks, the City of Reno, and Washoe County, local and regional population projections, direct interviews, and field survey.

units within the flood plain vary from typical urban residential developments, with densities of 3 to 6 dwelling units per acre to large lotresidences with lots generally 1/2 to 1 acre in size. Mobile homes were also classified as single family residences and as a result of field survey were determined to have an average density of 9 units per acre.

Commercial and industrial units comprise 11 and 5 percent respectively of the total flood plain units. While their numbers are small, they do encompass a large amount of acreage. Public facilities make-up the final 2 percent of flood plain units. Future units were not projected for the flood plain since the majority of existing units currently have new construction of support facilities outside of the flood plain due to cost and availability of land.

Value of Property

The market value of damageable property occupying the standard project flood plain, excluding lands, roads, utilities, and bridges, was conservatively estimated to be slightly in excess of $2.5 billion in 1982. Table 3 indicates that industrial and commercial properties contribute the highest values to this total, 42 percent and 31 percent respectively. Their property values reflect not only the structure value, but also inventory on hand, and fixtures and equipment. Currently about 19 percent of the total flood plain value is contained in the residential categories: structure and contents. Multiple residential comprises the largest portion of this percentage followed closely by single family homes. The last category, public facilities, contributes the final 8 percent of the total flood plain value.

FLOOD DAMAGES

Based on data presented in the preceding paragraphs, flood damages were computed by determining relationships between damages and depths, flows, and frequencies of flooding. The following will discuss these relationships at greater length.

Types of Damages

The principal types of flood damages considered in this analysis are those physical damages which are caused by inundation and losses or costs incurred in preparing for or fighting floods. Physical damages include damages to, or loss of, buildings and their contents, which include furnishings, equipment and fixtures, raw materials, goods in process, and finished products awaiting distribution. Other physical losses considered are damages to lot improvements such as clean up, as well as damages to roads, bridges, and utilities.

Physical losses incurred within the defined study flood plains were estimated for the following five land use categories: residential including single family, multiple, and mobile homes; commercial; industrial; public and semi-public, and agriculture. Monetary losses relating to residential include damages to structure, contents, yard areas, and private roads. Both commercial and industrial losses include damage to structures, inventories, fixtures, and parking areas. Public facilities sustain damages to structure content, and lot damage to public buildings as well as damage to roads, bridges, railroads, municipal water systems, and utilities. Damages to semi-public property include structure, content, and lot damage to churches

and recreation clubs. Agricultural losses include destruction of or damage to crops, damage to fences and irrigation systems, and lands requiring leveling and cleanup.

Additional costs are incurred during flood emergencies for evacuation and reoccupation, flood fighting, disaster relief, and extra duty for police, fire and military units. Intangible damages such as loss of life, impairment of health and living conditions and other conditions that cannot be evaluated in monetary terms have not been included in the damage analysis.

Methodology

Essentially, three steps were used in estimating flood damages which would occur in future years: First, estimates were made of the number and size of the physical units; secondly, assessments of the existing and future values of units were established; and finally, the damage susceptibility of those units were determined. By means of field surveys, aerial photography, and analysis of available data, the number and size of physical units in the flood plain were determined by hazard zones (25, 50, 100 and SPF events) for each of the following categories: Residential, commercial, industrial, public and semi-public facilities, and agriculture.

For residential, the number of physical units were established by field survey as well as actual counts from the assessor's rolls. In order to account for differences in damage value due to foundation heights and multi-level units, residential structures were classified as single family with densities ranging from one unit per two acre tract to six dwelling units per acre and multiple residences with an average density of 12 units per

acre. Single family residences were further classified as conventional or mobile home units while multiples were generally defined as garden apartments or duplexes. Projections of future residential growth were based on local and regional population projections in addition to direct interviews and land use plans.

The number and type of commercial establishments were determined by field survey, Washoe County assessment data, and through the use of aerial photos. Projections of future commercial growth were based on the general development plan of Reno-Sparks and Washoe County, and city and county zoning maps and ordinances. Estimating the number of industrial units was also accomplished by field survey and the use of aerial photos. By review of local land use plans and zoning maps and ordinances, future industrial growth was estimated.

Public facilities, which are comprised of a wide range of different types of physical units include roads, schools, government offices, parks, sewage treatment facilities, and other properties of public use. Closely related activities similar to the public facilities category, such as churches and recreation clubs were classified as semi-public. Field survey, aerial photos, and maps were used to determine the number of public facilities while projections for these activities in the future were based on local and regional population projections as well as direct interviews and land use plans. The number of damageable structures currently estimated to be in the standard project flood plain and projections of future units based on the above analysis are presented in Table 3.

TABLE 3

DAMAGEABLE PROPERTY VALUES IN THE STANDARD PROJECT FLOOD PLAIN - 1982 [1/]

(Thousands of dollars)

TYPE OF STRUCTURE	VALUE
SINGLE FAMILY RESIDENTIAL	222,625
MULTIPLE RESIDENTIAL	256,395
MOBILE HOMES	13,917
COMMERCIAL	780,412
INDUSTRIAL	1,083,177
PUBLIC FACILITIES	195,123
TOTAL	2,551,649

[1/] Excludes lands, roads, bridges, utilities, and railroads.

Acres of land under production, types of crops, length of growing season, and changes in yields per acre were the principal physical units of agricultural measurement. Damages to physical structures on agricultural lands were limited to farmhouses, barns, and related buildings with the number of these structures being obtained from county assessment rolls and field survey. Capital equipment for agricultural production is not considered since it is assumed to be mobile and can thus be removed from the hazard of most floods.

Agricultural land, located within the flood plain is primarily irrigated and native pasture as well as alfalfa. Evidence of inundation to agricultural acreage in the Truckee Meadows is due to moderately deep and low velocity flooding of short duration with some deposition of sand, silt, and debris. As a result of these conditions, it was determined that damages would result in the form of cleanup only which involves the mending or replacement of fences, repair of irrigaton systems, and the removal of debris.

The values of existing properties in the flood plain were obtained from assessment rolls supplied by th Washoe County Assessor's Office, and direct interviews with realtors and public officials. This information was updated by actual sales values when such data was available.

In estimating the future value of physical units subject to flooding, unit values of commercial, industrial, public, and agricultural properties were not increased over time. Increases in the total value of commercial, industrial, and public properties in the flood plain resulted from expansion of existing facilities as well as construction of new units which were evaluated as new development. With the exception of contents, the value of

residential structures and related properties also were not increased over time. Increases in their total value resulted from new development.

After the number of physical units and the value associated with each unit was determined, damage susceptibility relationships were established as a function of total value of each physical unit and the flood characteristics of the stream.

Depth-Damage Relationships

Depth-damage relationships describe the probable damages that will occur under different depths of flooding conditions, either as a percentage of the total value of damageable property or in the probable loss expected. The depth-damage relationships used in this analysis were derived from historical data when available. Otherwise this information was obtained from relationships established by insurance companies, other Corps districts, direct interviews, or projects with similar physical characteristics. These relationships were developed for individual land use categories and are dependent upon the type, age and condition of the structures, foundation heights, the localized characteristics of the terrain, and detailed cross sections of flood depths. Other factors considered in the flood damage analysis were velocity, duration, and debris content of flood waters.

Damage-Flow Relationships

Damage-flow relationships describe the probable flood damages expected for stream flows at various frequencies. They are derived by estimating the probable flood damages of several hypothetical floods of given stream flows.

Intermediate damage points are interpolated from these estimates on the basis of proportionate changes in the magnitude of stream flows. The probable flood damages that would result from a particular flow are estimated by describing the flood plain area associated with that flow, inventorying this area by damage category and depth of flooding and applying the appropriate depth-damage relationships for each damage category. Probable damages were determined for the 25-year, 50-year, 100-year, and SPF flood events.

Average Annual Damages

a. Without Project. -

Average annual damages are the expected value of damages for a given economic condition and point in time. They are determined by weighing the estimated damages from varying degrees of flooding by their probability of occurrence and may be approximated by measuring the area under the damage-frequency curve using standard mathematical integration procedures.

Probable average annual damages without the proposed project were estimated for the present year, the base year, and annually throughout the study period. Average annual equivalent damages for the period 1990-2040 were estimated on the basis of a 7-7/8 percent interest level, October 1982 prices, and standard discounting procedures.

b. With Project. -

The average annual damages under without project conditions would also occur under project conditions, since residual damages are the average

annual primary damages remaining under the with project condition. Under project conditions, the flow-damage relationship is the same, while the frequency-damage relationship changes due to an adjustment in the flow-frequency curve. In other words, damages are the same for both preproject and project conditions for any given flow in a flooded area. The flow is redefined, however, and becomes a less frequent event under project conditions.

Flood Insurance Program

The Flood Disaster Protection Act of 1973 (Public Law 93-234) requires that communities having flood-prone areas participate in the National Flood Insurance Program by July 1, 1975 or else they become ineligible for Federally related financing for projects that would be located in such areas. Participation in the regular flood insurance program requires local adoption and certification of land use regulations by the flood insurance and hazard mitigation. As a minimum, all new and replacement residential structures in the 100-year flood plain must have their first floor elevated one foot above the 100-year flood elevation and all new or replacement non-residential structures must be flood proofed up to the level of the 100-year flood.

Currently, the Cities of Reno and Sparks, as well as Washoe County, are enrolled in the emergency phase of the flood insurance program. This denotes that the flood hazard boundary maps have been published allowing property owners within these zones to purchase limited amounts of flood insurance.

As of the date of this report (February 1983), work has begun on updating the community's current status to the regular program. Part of this process involves the publication of flood elevations followed by a 90-day appeals period which is now in effect. After any appeals have been resolved, these elevations will become final and the flood insurance rate maps for the community will become effective. This entire process can take up to a year, but once enrolled in the regular program, the full limits of flood insurance coverage are available to property owners.

For the preproject condition, it is assumed that the first floor of all future development within the 100-year flood plain will be elevated to the level of the 100-year flood in compliance with the Flood Disaster Protection Act.

BENEFIT EVALUATION

Benefits which accrue from the evaluation of flood control projects include intensification benefits, location benefits, savings in flood proofing costs, and N.E.D. employment benefits. The only pertinent benefit category for this study, however, is inundation reduction benefits.

Description of The Selected Plan

Table 4 provides a summary of the average annual equivalent preproject damages, residual damages, and project related benefits for the Selected Plan. Several plans were initially considered and evaluated. The Selected Plan will provide a 100-year or greater level of protection by various means including channel enlargement, bridge modification, and the removal of various obstructions within the river channel.

Inundation Reduction Benefits

Inundation reduction benefits for the Selected Plan are estimated by evaluating damages with and without the proposed project. Primary tangible flood damage reduction benefits for the plan is the difference between the equivalent average annual flood losses without the project and the residual average annual losses with the project. Economic criteria and projections used in arriving at the benefit estimates encompass recent evaluation guidelines, the Flood Disaster Protection Act of 1973, and the Water Resources Development Act of 1974.

TABLE 4

SELECTED PLAN
AVERAGE ANNUAL EQUIVALENT DAMAGES AND BENEFITS

(Thousands of dollars)

DAMAGES AND BENEFITS	AVERAGE ANNUAL EQUIVALENT (7-7/8%)	UNDISCOUNTED DAMAGES AND BENEFITS						
		1982	1990	2000	2010	2020	2030	2040
I. PREPROJECT DAMAGES								
RESIDENTIAL	1,744.8	1,463.0	1,744.8	1,744.8	1,744.8	1,744.8	1,744.8	1,744.8
Contents	944.5	449.1	707.2	896.1	1,159.0	1,265.2	1,265.2	1,265.2
COMMERCIAL	3,324.0	2,429.1	3,324.0	3,324.0	3,324.0	3,324.0	3,324.0	3,324.0
INDUSTRIAL	14,425.2	3,991.8	14,425.2	14,425.2	14,425.2	14,425.2	14,425.2	14,425.2
PUBLIC AND SEMI-PUBLIC	1,131.9	1,118.6	1,131.9	1,131.9	1,131.9	1,131.9	1,131.9	1,131.9
EMERGENCY COSTS	112.5	65.4	112.5	112.5	112.5	112.5	112.5	112.5
TOTAL	21,682.9	9,517.0	21,445.6	21,634.5	21,897.4	22,003.6	22,003.6	22,003.6
II. RESIDUAL DAMAGES								
RESIDENTIAL	1,098.2	917.7	1,098.2	1,098.2	1,098.2	1,098.2	1,098.2	1,098.2
Contents	599.5	286.0	449.4	568.8	735.1	802.3	802.3	802.3
COMMERCIAL	2,052.0	1,364.7	2,052.0	2,052.0	2,052.0	2,052.0	2,052.0	2,052.0
INDUSTRIAL	8,407.3	2,328.8	8,407.3	8,407.3	8,407.3	8,407.3	8,407.3	8,407.3
PUBLIC AND SEMI-PUBLIC	659.8	652.6	659.8	659.8	659.8	659.8	659.8	659.8
EMERGENCY COSTS	34.0	23.6	34.0	34.0	34.0	34.0	34.0	34.0
TOTAL	12,850.8	5,573.4	12,700.7	12,820.1	12,986.4	13,053.6	13,053.6	13,053.6
III. BENEFITS								
RESIDENTIAL	646.6	545.3	646.6	646.6	646.6	646.6	646.6	646.6
Contents	345.0	163.1	257.8	327.3	423.9	462.9	462.9	462.9
COMMERCIAL	1,272.0	1,064.4	1,272.0	1,272.0	1,272.0	1,272.0	1,272.0	1,272.0
INDUSTRIAL	6,017.9	1,663.0	6,017.9	6,017.9	6,017.9	6,017.9	6,017.9	6,017.9
PUBLIC AND SEMI-PUBLIC	472.1	466.0	472.1	472.1	472.1	472.1	472.1	472.1
EMERGENCY COSTS	78.5	41.8	78.5	78.5	78.5	78.5	78.5	78.5
TOTAL	8,832.1	3,943.6	8,744.9	8,814.4	8,911.0	8,950.0	8,950.0	8,950.0

Intensification Benefits

Intensification benefits occur when as a result of a project, lands are able to be used more intensively. This condition would occur when the reduction of the risk of flooding permits a user to invest additional labor or capital in the land. For example, where agricultural land is now being used as pasture and would, because of the project, convert to a higher income producing crop such as a vegetable crop intensification benefits would result. It was determined that the flood hazard problem in the Truckee Meadows. However, is an insignificant constraint when compared with other limiting factors which exist in the area such as the availability of agriculture water and urban encroachment.

Location Benefits

According to certain provisions stated in ER 1105-2-351, a location benefit is the value of making flood plain land available for new uses by reducing flood hazards to activities which would use the flood plain only with protection. Three methods are available to measure location benefits: The net income approach, which measures the net income of the displaying activity less the decreases in net income of the displaced activities; the threshold level approach, which computes reduced flood damages to new activities created by a higher level of protection above the economically indifferent threshold level; and the market value approach, which is the difference in the market value of flood plain with and without a plan, less residual damages to induced activies.

For purposes of this analysis, only the flood plain area adjacent to the Truckee River and within the unimproved portion of the Truckee Meadows was considered for potential location benefits. From discussions with Washoe County officials and from inspection by Corps personnel of the current land uses in the flood plain, it is believed that no new uses of the flood plain would result because of a project. The present land use and proposed growth of the area are not now affected by the current flood hazard problem, and the project is not expectd to alter future planned land use. Therefore, location benefits have not been claimed for the Selected Plan.

Savings In Flood Proofing Costs

As indicated earlier, the flood disaster protection act requires all new and replacement units to be constructed with their first floor elevated at or above the 100-year flood level. If a proposed project would provide protection to or above the 100-year level, future development would not be required to incur the additional expense of flood proofing, and the savings could be counted as a project benefit. However, at the current rate of development in the Reno-Sparks metropolitan area the study flood plains will essentially be developed by project year one, units constructed between the study and base years would be flood proofed in accordance with the Flood Disaster Protection Act. However, monetary savings accuring to the proposed project would be insignificant since only replacement units would forego required flood proofing and related costs. For this reason, savings in flood proofing costs were considered, but not included as a project benefit.

N.E.D. Employment Benefits

The Area Redevelopment Act, Public Law 87-27, 87th Congress, 1st session, and its successor, the Public Works and Economic Development Act of 1965, Public Law 89-136, 89th Congress, provide for the Federal Government to cooperate with the states to help areas of substantial and persistent unemployment and to take effective steps in planning and financing their economic development. Federal assistance should enable such areas to enhance the domestic development and expansion of new and existing facilities and resources. The role of the Corps of Engineers in this program is set forth in EC 1105-2-42, dated November 28, 1975, which also specifies the criteria to be used for project formulation and evaluation. It states that in addition to the criteria now in use, estimates of benefits may incude an amount equivalent to the part of the construction costs which represents wages and fringe benefits to workers who, in absence of the project, would be unemployed. Washoe County was designated as an area eligible for assistance under the Public and Economic Development Act by the Economic Development Administration of the U.S. Department of Commerce in July 1976. The county, however, in August 1979, lost this designation and as a result N.E.D. employment benefits may not be considered at the time of this analysis.

Section H

Cultural Resources Literature Review

SECTION H
CULTURAL RESOURCES LITERATURE REVIEW
TRUCKEE MEADOWS INVESTIGATION

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Tables

1. INTRODUCTION

a. This study was conducted in accordance with Corps of Engineers Regulation ER 1105-2-50. It includes a brief literature search of historical, archeological and ethnographic reports; an examination of archeological site records on file at the Nevada State Museum; and contact with certain persons knowledgeable of the project area.

b. Should the project be authorized for advanced engineering and design studies, a more detailed cultural resources investigation will be undertaken and will include either a reconnaissance or intensive field survey of proposed project features, a more in-depth literature search, and National Register evaluations as outlined in ER 1105-2-50.

c. This report is intended to be a preliminary planning document in order to give the Corps of Engineers and the Nevada State Historic Preservation Office an idea of the types of cultural resources which might be impacted by the currently formulated project. It will also assist the Corps of Engineers in developing a Scope of Work and Cost Estimate for future field investigations. It should not be regarded as a final or exhaustive study since specific project alignments have not yet been selected.

2. PROJECT SUMMARY

a. The Truckee Meadows (Reno/Sparks Metropolitan Area) Nevada, Investigation was authorized in 1964 by a Senate Public Works Committee resolution to determine the feasibility of providing additional flood protection for the Truckee Meadows area at and below Reno, Nevada.

b. Although the total study area is a 3,600 square mile segment of the Truckee River Basin in Washoe and Storey Counties, this cultural resources report concentrates on those areas likely to be impacted by construction or construction-related activities. This includes channel improvements, setback levees, combined with bridge replacement in the downtown area, and a detention basin in the University Farm area. The proposed bridge replacement consists of removing the existing Lake, Center, Virginia, Sierra, Arlington, and Booth Street Bridges and constructing new full-span replacement bridges.

3. PREHISTORIC AND ETHNORGRAPHIC BACKGROUND

a. Prehistoric. - The prehistoric chronology of the Truckee Meadows is summarized in Table 1 (James, Brown and Elston 1982:13).

(1) The earliest phase, Tahoe Reach, is suggested to date back in time to circa 6,000 BC. Sites are characterized by large basalt bifaces, fluted projectile points and/or Parman Lake points, and often occur near late Pleistocene and Anathermal Lakes. A reexamination of artifact collections from around the Truckee Meadows indicates the presence of Tahoe Reach-like specimens. Tahoe Reach sites have also been found near Squaw Valley, California, in northwestern Nevada, along the Humboldt River, and north of Reno near ancient Lake Laughton (Miller and Elston 1979:12,13).

(2) Tahoe Reach is followed by the Spooner Phase from 2000-5000 BC. Spooner sites are identified by seed processing with the mano and metate, and by Pinto and Humboldt projectile points used as atlatl darts

FROM: James, Brown & Elston 1982

TABLE 1

CULTURAL PHASES OF THE WASHOE REGION

PHASE	TIME MARKERS	AGE	CLIMATE
Washo-Late Kings Beach	Desert Side-notched and Cottonwood Series points, chert cores, utilized flakes and other small chert tools, shallow saucer-shaped house pits.	Historic Contact-AD 1200	Neoglacial;wet and cool, but with little summer precipitation.
Early Kings Beach	Eastgate and Rose Spring Series points, chert cores, utilized flakes and other small chert tools, small shallow saucer-shaped house pits.	AD 1200-AD 500	Nonglacial, dry, trees growing in former bogs, Tahoe may often not overflow.
Late Martis	Corner-notched and eared points of the Martis and Elko Series? Large side-notched points? Large basalt bifaces and other basalt tools, steep-sided house pits.	AD 500-500 BC?	Neoglacial; wet but not necessarily cooler, increased summer precipitation.
Middle Martis	Steamboat points, other types in Elko-Martis Series? Large basalt bifaces and other basalt tools, steep-sided house pits.	500 BC?-1500 BC	Possible warm, dry interval centered on 1500 BC.
Early Martis	Contracting Stem points of the Elko-Martis Series? Large basalt bifaces and other tools. Light colored basalt artifacts?, steep sided house pits?	1500 BC-2000 BC	Beginning of Medithermal; Neoglacial, wetbut not necessarily cooler, increased summer precipitation, Tahoe begins to overflow.
Spooner	Points in the Pinto and Humboldt Series, light colored basalt artifacts.	2000 BC-5000 BC	Altithermal; generally hot and dry, Tahoe does not overflow for long periods of time.
Tahoe Reach	Parman-like points (Great Basin Stemmed Series).	6000 BC	Anathermal; warming trend, climate similar to later Neoglacial intervals.

(ibid:13). Both the Spooner and Tahoe Reach phases are lacking in cultural remains which would allow further clarification of the earliest prehistoric occupations.

(3) Beginning with the early Martis Phases (1500-2000 BC), more information becomes available. Early Martis-Late Spooner is suggested by Price (1963:40) to be the time when ancestors of the present-day Washo Indians separated from other Hokan-speaking groups and settled in a territory they were to occupy for the next 4,500 years. Martis sites contain large basalt bifaces and other tools, steep-sided house pits, and Elko-Martis series projectile points (James, et al 1982:13). Martis features also include storage pits, rocklined fire hearths or earth ovens, use of the mano and metate, and flexed burials with grave goods (Miller and Elston 1979:13). The Martis Phase has a greater density of winter villages and permanent campsites than any of the other prehistoric phases. This may be attributed to cool, moist climactic conditions which allowed higher population density (ibid:13,14).

(4) The Kings Beach Phase follows Martis and continues to historic contact. Early Kings Beach is the likely antecedent of the ethnographic Washo. During Kings Beach there are significant climatic changes including a drying trend and a cultural shift from large game hunting to plant food processing and fishing (Price 1963:40). The hopper mortar and bedrock mortar are used in conjunction with the mano and metate (Miller and Elston 1982:14), and may indicate adoption of technology from the west. Price (1963:14) states the lack of transitional sites from Martis to Kings Beach is due to a shift in subsistence. Martis sites were often located along game trails and Kings Beach sites were founded closer to plant and fish resources.

b. Ethnographic. -

(1) For possibly as long as 4,500 years, the Truckee Meadows area was occupied by a Hokan-speaking people; later known as the Washo.

(2) The Washo occupied the eastern slope of the central Sierra Nevada in what was one of the most productive areas of the Great Basin, and had a territory whose maximum area covered some 12,000 square miles. They ranged from the western margins of the arid Great Basin to the densely wooded eastern slope of the Sierra Nevada, and into the headwaters of the Mokelumne, Calaveras and Stanislaus Rivers in the high Sierras although the western limit is usually considered to be the Sierra crest (Barrett 1917:6).

(3) These were a hunting and gathering people who made seasonal rounds in search of food (Tables 2 and 3). They occupied two completely distinct environments: from the timbered, watered Sierras to the semi-desert basin (ibid). The valleys were inhabited only in the winter for extended periods of time, with the people living in 10-15-foot-diameter conical dwellings (Elston and Turner 1968:8). The Washo were primarily a Great Basin people, although they had contact with California groups such as the Maidu and Miwok (Barrett 1917:8). Affinities to California included the use of acorns, the bedrock mortar and cobblestone pestle, coiled basketry, semi-subterranean ceremonial houses and conical slab houses. From the Great Basin they took most of their foods and methods of hunting game, and twined basketry (ibid:24,25). Through their geographic isolation, the Washo and no known contact with other Hokan-speaking groups (Price 1963:40).

FROM: James, Brown & Elston 1982

TABLE 2

IDEALIZED WASHO SUBSISTENCE ROUND ACCORDING TO DOWNS (1966)

TIME	ACTIVITY	RESOURCE UTILIZED
Early Spring	Young people to Lake Tahoe	White fish, marmots, early spring plants
	Others still in winter village	Near pinyon groves - Indian potatoes Foothills - wild spinach, wild lettuce Marshes, hot springs - tules
Early Summer	Almost all Washo go to Lake Tahoe	Spawning fish
Mid-Summer	Individual families to higher mountain meadows	Vegetable foods, fish, game, quail
	Individual families to lowlands; camps along Carson or Truckee	Minnows, seed grasses
Late Summer	Most people go east into valleys	Plant foods, especially seed grasses
	A few families go west into foothills	Grass seeds, chokecherries
Fall	Families in foothills	Deer, acorns
	Northern bands to Pinyon hills NW of Reno	Pinyon nuts, jackrabbit, deer, mountain sheep
	Southern bands go to Pinyon hills SE of Minden and Gardnerville	Pinyon nuts, jackrabbit, deer, mountain sheep
Late Fall Early Winter	A few families remain in Pinyon hills; most families to winter villages at eastern edge of Sierras.	Stored food, occasional small and big game hunting, fishing

FROM: James, Brown & Elston 1982

TABLE 3

ALTERNATIVE SEASONAL ROUNDS

	SPRING	SUMMER	FALL	WINTER
Area	Long Valley Cr.	Long Valley Cr.	Eastern edge of Sierra, Honey Lake Valley	Long Valley Cr.
Resource	Sucker Runs Early spring plants Waterfowl Small game	Sucker Runs Seed grasses Waterfowl Small game	Deer Acorns Rabbits Waterfowl	Winter village in valley (stored food, waterfowl, some small game)
Area	Lake Tahoe	Truckee Meadows	(1) East slope of Sierras (2) Truckee Meadows (3) Virginia Range	Along Truckee River up to Verdi
Resource	Fish runs Early Spring plants	Seed grasses Small mammals Waterfowl Fish	(1) Deer (2) Rabbits (3) Pine nuts	Winter spawning of cutthroat trout
Area	Washoe Valley	Washoe Valley	(1) East slope of Sierras (2) Washoe Valley (3) Virginia Range	Near Hot Springs in Washoe Valley
Resource	Fish runs Early spring plants Waterfowl Small mammals	Seed grasses Small mammals Waterfowl	(1) Deer (2) Rabbits, waterfowl (3) Pine nuts	Winter village (stored food, waterfowl, some small game)

(4) Prior to 1858, the Washo outnumbered the white population. Although there had been contacts with trappers, explorers and emigrants as early as 1825, and disruption caused by an influx of miners and Mormons beginning in 1847, it was the discovery of the Comstock Lode that caused the greatest damage to Washo life. The influx of over 20,000 miners into the Virginia City area meant the Washo were no longer the dominant group in their homeland and by the end of 1858, they had lost much of their territory. By the 1920s, the last nomadic bands had become sedentary (ibid:47-49). Chinese laborers brought into work on the railroad (Barrett 1917:44) also impacted Washo culture. The Ghost Dancė may have moved west from the Northern Paiute, through the Washo and on to the Maidu (Heizer and Whipple 1917:58).

4. HISTORICAL BACKGROUND

a. The first non-Indians known to visit what is now the State of Nevada, were some 40 trappers led by the famous frontiersman and traveller, Jedediah Smith in his expedition of 1825-26. Smith's party traveled along the Humboldt River and then south into California (Thompson and West 1881:20,21), missing the Truckee River entirely. The Smith expedition was followed by the fur trapping parties of Ogden in 1831; Sublette in 1832; Bonneville and Walker in 1833; and Carson in 1833. Captain J. B. Barthleson led the first group of emigrants across Nevada en route to California in 1841. It was not until 1844 that Fremont named Pyramid Lake as he was camped near the Truckee River near present-day Wadsworth. Fremont also named Lake Tahoe, in 1845, what he supposed to be an Indian name (ibid:21-25).

b. In 1844, the Stevens-Murphy emigrant party followed the Truckee River into California, establishing what later became an important overland route (James et al 1928:7). They were guided by an Indian named "Truckee" after whom the river was named (Thompson and West 1881:24). Fremont had previously named the river the Salmon Trout (ibid:622).

c. The Washoe Valley and Truckee Meadows were thus known to the earliest emigrants going to California. The first permanent settlement in Washoe County was made by a Mormon named Jamison who established Jamison's Trading Post and Station on the Truckee River. In 1857, Stone and Gates' Crossing, now Glendale, was founded. By 1860, there were 543 settlers in Washoe County (ibid:622:625).

d. Myron Lake purchased a crossing over the Truckee River in 1861, later known as Lake's Crossing and now the site of the Virginia Street Bridge. Through negotiations with the Central Pacific Railroad, Lake established the townsite of Lake's Crossing in exchange for a railroad right-of-way (McMullen 1981:49). Lake's Crossing later became the town of Reno.

e. Completion of the transcontinental railroad brought increasing prosperity to the Washoe Valley. After World War I, the automobile highway system also linked Nevada with neighboring states as the railroad had in the past. Today, the area is both a tourist attraction due to legalized gambling and a home for its many residents.

5. PREVIOUS ARCHEOLOGICAL STUDIES

a. Initial archeological investigations in the Truckee Meadows area were not conducted until the 1950s. Since that time, several specific studies have been undertaken, but no systematic surveying of the overall region has occurred.

b. The most extensive field survey in the Truckee Meadows was conducted by Elston in 1967 for the proposed Steamboat Reservoir between Huffaker Hills and Steamboat Hot Springs (Elston and Turner, 1968). Thirty-one (31) prehistoric sites were recorded, of which 6 are within the present Corps of Engineers Truckee Meadows project area.

c. Other studies within the proposed project area include the U.S. Highway 395 realignment (Townsend and Elston, 1975), and surveys by the Bureau of Land Management (BLM Project CR3-351) and the Nevada Department of Transportation (NDOT-028-80C).

d. The only major excavations that have taken place in the past few years were at the Glendale Site (WA-2065) and the Vista Site (WA-3017).

e. The Glendale Site (WA-2065) was excavated by the Nevada Archeological Survey in 1977. Intermittent prehistoric occupation at WA-2065 appears to have begun about 5000 BC, but was concentrated between 500 BC. An historic component from the 19th Century Nevada Insane Asylum was also excavated. (Miller and Elston, 1979).

f. The Vista Site (WA-3017) is an early Kings Beach site occupied primarily between 1100-1400 AD. WA-3017 most likely was utilized as a winter village. An historic component consisting of Chinese railroad camp artifacts also occured at the site (James et al 1982).

g. A preliminary review of cultural resources along the Truckee River from the Nevada-California stateline to West Reno was completed by Rusco in 1981.

6. RECORDED CULTURAL RESOURCES

a. Downtown Bridges:

(1) Lake Street Bridge. - The Lake Street Bridge was constructed in 1937 by the Silver State Construction Company for the Nevada Department of Highways. The bridge, as designed, is a concrete continuous Tee Beam, 183 feet long and 60.7 feet wide, and cost $49,378 (NAER 1981).

(2) Center Street Bridge. - The Center Street Bridge was built in 1926 by the firm of James S. Jensen. The 2-span, reinforced-concrete bridge is 162 feet long and 62 feet wide. The bridge cost $57,034 to construct. It was later made a memorial bridge for William O'Hare Martin, a prominent local citizen (NAER 1982).

(3) Virginia Street Bridge. - The Virginia Street Bridge was constructed in 1905 by the Cotton Brothers of Oakland, California, and was designed by John B. Leonard of San Francisco. The 2-span, 146 foot long bridge was the first reinforced-concrete bridge in Nevada. It cost $37,737

(NAER, 1981). The bridge represents a unique architectural and engineering style and was placed on the National Register of Historic Places in 1981. The bridge site is at the original Lake's Crossing, which existed prior to the City of Reno.

(4) Sierra Street Bridge. - Also knwon as the Emmet D. Boyle Memorial Bridge, this bridge was constructed in 1937 by J.S. Knapp Company of Oakland, California, at a cost of $66,182. The bridge consists of a continuous steel girder concrete deck and is 136 feet long and 44 feet wide (NAER, 1981).

(5) Arlington Street Bridge. - There are two bridge crossings at Arlington Street, the North Bridge and the South Bridge. The North Bridge was constructed in 1920 by the George Pollack Company of Sacramento for $18,600. The 3-span, concrete beam structure was widened twice; in 1938 and again in 1967. The existing South Arlington Bridge was built in 1938, replacing the original span constructed in 1921. also of reinforced concrete, South Arlington Bridge was built by Nevada Rock and Sand Company of Reno for $20,11.50.

(6) Booth Street Bridge. - Previously known as the Riverside Bridge, this reinforced crossing was built in 1920 by J.S. Hoffman of Minden, Nevada for $32,098. The bridge replaced the wooden "Electric Light Bridge" owned by Reno Power, Light and Water Company (NAER, 1982).

7. <u>ARCHEOLOGICAL SITES</u>

a. WA-1456: Bella Vista Ranch Site. Elevation 4400'. Large village with "tons" of sandstone. Contains blades, points and chipping waste. 200 meters x 1/2 mile (Elston 1968:15,16).

b. WA-1482: Elevation 4560'. Chipping area on high flat. 200 meters long (ibid).

c. WA-1491: Elevation 4420'. Lithic waste site with two bedrock mortar pits. Destroyed (ibid).

d. WA-1492: Elevation 4420'. Chipping waste site near WA-1491. Destroyed (ibid).

e. WA-1493: Elevation 4420'. Grinding stone site with basalt flakes. Largely destroyed (ibid).

f. WA-1495: Barn Site. Elevation 4400'. Large workshop and village site on knoll with 2' deep deposit. 200 x 100 meters (ibid).

g. WA-1489: Elevation 4550'. Small chipping site. 25 x 50 meters.

h. WA-1701: Elevation 4395'. Isolated Rosespring Contracting Stem projectile point circa 500-1300 AD.

i. WA-2065: Glendale Site. Elevation 4440'. Village site excavated in 1977. Determined eligible for the National Register.

k. WA-2645: Elevation 4500'. Lithic scatter. 25 meter area.

l. WA-2667: Elevation 4395'. Surface lithic scatter with ground stone. 1414 square meters.

m. 2673 a-e: Multi-component site:

(1) Elevation 4495': Isolated mortar.

(b) Elevation 4595'. Lithic site with ground stone and diagnostic artifacts.

(c) & (d) Elevation 4610': Lithic site with ground stone and diagnostic artifacts.

(e) Elevation 4625';" Lithic site with ground stone and diagnostic artifacts.

n. WA-2674: Elevation not given. Lithic site with dense scatter of tools and ground stone. 600 x 150 meters.

o. WA-2675: Elevation not given. Historic Chinese walls constructed circa 1869.

p. WA-2676: Emigrant Trail Site. Site record not complete.

q. WA-2017, WA-3018: Vista Site. Winter village and historic Chinese railroad camp components (James, et al 1982).

8. SUMMARY

a. Bridges. - All six bridges - Lake, Center, Virginia, Sierra, Arlington and Booth have been recorded by the Nevada Historical Society on North American Engineering Record (NAER) forms. Of these, only the Virginia Street Bridge has been listed in the National Register of Historic Places. Robert Nylen (pers. commun 1982) stated he does not consider the other five bridges to be historically significant. There appears to be strong opposition (ibid; Becker 1982, pers comm.) to removal of the Virginia Street Bridge based upon its historical importance.

b. Archeological Sites. - A number of prehistoric sites have been recorded in the area of proposed levee construction although none appear to be at specific levee locations. Since that area has not been systematically surveyed, it can be expected that additional and possibly significant prehistoric sites will be located if later studies are conducted, including winter village sites at higher elevations. Portions of an historic emigrant trial may also be impacted.

9. PERSONAL COMMUNICATIONS

Becker, Alice

1982 Nevada State Historic Preservation Office

Nylen, Robert

1982 Nevada Historical Society

10. BIBLIOGRAPHY

Barrett, Samuel A.

1917 "The Washo Indians" In Bulletin of the Public Museum of Milwaukee, Volume 2, Number 1, p 1-52.

Elston, Robert G. & David Turner

1968 An Archeological Reconnaissance of the Southern Truckee Meadows, Washoe County, Nevada. Reno, University of Nevada. 32 pp.

Heizer, Robert F. & M. A. Whipply

1971 The California Indians. Berkeley, University of California Press. 619 pp.

James, Steven R., Bonnie Brown and Robert G. Elston

1982 Archeological Investigations at the Vista Site (26 WA 3017), Washoe County, Nevada. Silver City, Intermountain Research, 118 pp.

McMullin, Nancy

1981 "Reno's Virginia Street Bridge: Its Historic and Engineering Significance" In Washoe Rambler, Volume 5 Number 2 p. 48-54.

Miller, Margaret M. and Robert G. Elston, et al

1979 The Archeology of the Glendale Site (26 WA2065): A Report to the Nevada Department of Highways. Reno, University of Nevada Archeological Survey. 343 pp.

TABLE 5
Recreation and Fish and Wildlife Use and Benefits
7-7/8 Interest Rate

	RECREATION			FISH & WILDLIFE				
Year	Est. 1/ Rec Use	Discounted Rate 7-7/8%	Discounted Use	Fishing Use	Disc. Use	Nonconsump Use	Migratory Birds	Endang. Species
1990	684,000	0.3228	220,795	25,000	1.0X	169,000	415,000	421,000
2000	713,000	0.3722	265,379	25,000	25,000	169,000	415,000	421,000
2010	742,000	0.1744	129,405	25,000	25,000	169,000	415,000	421,000
2020	770,000	0.0817	62,909	25,000	25,000	169,000	415,000	421,000
2030	799,000	0.0383	30,602	25,000	25,000	169,000	415,000	421,000
2040	828,000	0.0107	8,860	25,000	25,000	169,000	415,000	421,000
						169,000 3/x		
			717,950		25,000	$4.30 2/=		
	travel cost value		x 27.63		x $27.63=	$726,700		
					$690,750		(1982 price level)	
			$19,836,959		($691,000)	($727,000)		
					Fishing		$691,000	
					Nonconsumptive		727,000	
					Migratory Birds		415,000	
					Endangered Species		421,000	
TOTAL RECREATION BENEFITS			$19,836,959 ($19,800,000)		TOTAL FISH & WILDLIFE		$2,254,000 ($2,250,000)	

1/ Interpolated use from estimated use figures on MPU table.
Est. use for 2040 = 828,000 - 684,000 (1990) = 144,000/5 decades = 28,800.

2/ Table VIII-3-2 Principles and Guidelines, p.85 - 68 points, Table 3-1 70 pts = $4.30, Jul 82 price level. Amount of use is limited by capacity of Steamboat Marsh (includes 20,000 days use on Steamboat Creek).

3/ 169,000 = 149,000 annual recreation days (based on an 85-space parking lot in Steamboat Marsh) area and 20,000 annual recreation days of use along Steamboat Creek (FWS).